SCHOOL SCIENCE AND MATHEMATICS

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FACT AND FICTION IN NATURE STUDY

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Whoever undertakes the study of Nature from books must learn to discriminate between Natural History and nature stories. The latter are interesting and enjoyable, but they may be misleading. Many ascribe to wild animals habits and traits, whether good or evil, which they do not possess, while others endow them with a degree of intelligence that is not justified by the facts.

It is only within the last half-century that the study of wild animals was undertaken on a scientific, fact-finding basis. What was written on the subject before the closing years of the nineteenth century may be quite accurately described as "unnatural history." It consists of three principal ingredients: Fact, fiction and superstition. Much of this rubbish is of ancient origin and was handed down from generation to generation since the time of the elder Pliny who perished in the eruption of Vesuvius in 79 A.D.

No other subject of equal importance and universal interest is so encumbered with absurdities and superstitious nonsense. Alchemy no longer distracts the researches of the chemist and astronomy has long since been divorced from astrology, but millions of people still believe that certain wild animals possess supernatural powers or are in league with the devil.

As a result of studies by investigators who employed scientific methods and sought the truth first-hand after rejecting what had been written previously, Natural History has become one

of the most interesting and fascinating subjects for study and research. The wilderness, instead of being infested by ferocious and bloodthirsty monsters that possess supernatural powers and lie in wait to pounce upon, kill and devour human prey, is revealed as the abode of a large number and variety of species, none of which need be greatly feared, while many of them respond quickly to kindness and friendly advances and seem to desire the friendship and companionship of mankind.

Amateurs and would-be naturalists should begin their studies with a clean slate. They should not be hampered by borrowed convictions and seek to verify them. Rather, they should adopt the attitude of the philosopher who expects nothing but accepts the facts which he discovers. They should always bear in mind that nothing is supernatural; that whatever is, is natural and that all phenomena have a natural explanation.

It would seem that in our present state of enlightenment superstition should find no credence and that it is unnecessary to point out, for instance, that a black cat crossing the road is not a "sign of bad luck," nor of anything else except the cat's desire to go some place, yet this absurdity still is widely believed. Likewise many still are fearful of "unlucky days and unlucky numbers." Many hotels have no rooms numbered 13 because superstitious would-be-guests refuse to sleep in them.

Only ignorance and superstition can account for the belief that the howling of a dog is an omen of death; that horse hairs left in the water turn into worms; that groundhogs (woodchucks) emerge from their burrows on "Groundhog Day" (February 2) to look for their shadows; that snakes "charm" their prey, or swallow their young to save them when danger threatens.

Everybody should know that dragons and unicorns never existed on earth; that there are no hoop-snakes; that porcupines do not "shoot their quills"; that beavers do not use their tails as trowels; bears do not suck their paws for food while hibernating; bats do not carry bedbugs nor bring "bad luck" to the people whose homes they enter; neither do they become entangled in women's hair unless they are put there; a rabbit's foot does not bring "luck" to its possessor and it does not make a particle of difference over which shoulder we look at the new moon.

There are many other erroneous and absurd conceptions concerning wild animals that should be removed. The age of a

rattlesnake is not indicated by the number of rattles on its tail; neither does the age of a male deer correspond to the number of "points" on its antlers. A set of deer antlers from Texas contains eighty-four points and one from Wisconsin has one hundred and three points. Neither of these deer may have been more than six years old.

There is no authentic record of any man, woman, or child having been attacked by a wolf, or a "pack of wolves," in the wilderness. Wolves, bears, alligators and other so-called "ferocious" beasts really try to keep out of man's way and none of them attack mankind without serious provocation, as when their young ones are threatened, and many do not attack human beings even in defense of their young. In captivity, however, many species have been known to attack their keepers without provocation after they were mature. Grown-up wild animal pets should never be trusted.

Skunks and rattlesnakes, much feared where they are found, never go out of their way to attack an enemy. They use their weapons only in self-defense, or when they fear an attack. It is always discreet to withdraw from their presence, but this need not be done precipitately, for they do not pursue an enemy. The bite of a skunk is not any more dangerous than that of any other animal, wild or domestic, but every animal bite should be treated immediately with an antiseptic to guard against infection. The bite of a rattlesnake is a serious matter that calls for prompt and skillful attention. Whiskey is not an antidote for snake-bite. Tarantulas are fearsome looking creatures and their bite is slightly poisonous, but it is not very dangerous nor very painful.

The number of such fallacies is unlimited, as the questing student who prosecutes his researches among living subjects will discover for himself. Common sense is the best antidote for superstition.

It is not necessary to go far afield for elementary lessons in Natural History. There is a lesson of intense interest in every ant-hill and I know of no better cure for the "blues" than to lie in the grass in front of a hive and observe the bees at work on a warm day when the nectar is flowing. If the observer is calm and quiet the bees will not molest him, but a scout will often buzz around on a tour of inspection. If the student sits still and makes no hostile move it will soon depart. If, however, the bee is slapped at and not killed or stunned, it will attack promptly

and be reinforced from the hive on the double-quick.

Kindness and calm, gentle approach are the magic that wins the confidence of wild creatures. Many animals are attracted by the human voice. Soft, unhurried speech seems to charm them. Some pause in whatever they are doing and listen to the human voice as intently as we do to a symphony. The easiest way to approach is to speak, or whistle, softly while moving slowly, but not directly, toward the object. I have employed this method many times to approach within touching distance of a chipmunk or ground squirrel and I know of an instance when a young woman by this means approached a woodchuck that was standing erect at the entrance to its burrow and was permitted to stroke its back. Similar adventures will befall anyone who really loves, and is interested in, "Our kindred of the wild," whom we, in our egotism, refer to as "the lower animals." Love of wild animals, like virtue, brings its own reward and the nature-lover who knows mammals and birds will never be lonely in the wilderness, no matter how far he may be from human companionship.

True descriptions of the lives and habits of wild animals will always be the most fascinating nature stories and they are most enjoyable when they are read in the original edition; that is, from Nature itself. No written description of a robin, for example, can give the student the pleasure and thrills that may be experienced by observing the bird itself. However, the opportunity for first-hand study is denied to some interested students and limited to many others. These must, by necessity, obtain the information from books and other second-hand sources. For this reason, and others, Natural History should be incorporated in the curriculum of our common schools, either as a separate subject or in connection with work in zoology or general science. It should not be displaced by miscellaneous nature studies.

Present state programs for the conservation of wild life are inadequate and little progress will be made in that direction until the masses learn what it is all about and are convinced that it will add materially to the welfare and enjoyment of the people.

Flashlight with featherweight storage batteries gives 2400 hours of steady light, casting a 1,000-foot beam before becoming depleted. To recharge this 4½-pound flashlight, it is simply plugged into a cigar lighter in any automobile.

THE EXHAUST BAROMETER IN AIR PRESSURE DEMONSTRATIONS

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If a picture is worth ten thousand words, as the Chinese say, then an object, particularly a moving one, ought to be worth ten thousand pictures. However, some pupils stick to their early verbal conditioning and say that suction pulls even after they have seen models perform. It is desirable, therefore, to improve air pressure demonstrations by showing what happens within appliances.

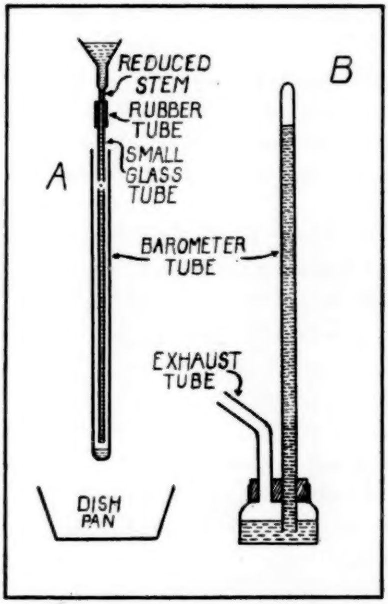


Fig. 1. A—Filling the barometer tube.
B—The exhaust barometer.

Of considerable value for this purpose is the exhaust barometer. This instrument resembles the Torricellian barometer except for the mercury well, which is enclosed and may be connected to a device to be tested.

An exhaust barometer may be made easily in the laboratory. Figure 1B shows the materials to be used and the general outline of assembly. Following are a few suggestions:

Usually, when a barometer tube is filled with a funnel, air bubbles shorten the final column. This may be avoided by slipping a long glass tube of small diameter to the closed end of the barometer tube as in Figure 1A. A funnel which has its shank drawn out is connected to this small tube with a bit of rubber tubing long enough to allow the thumb and forefinger to act as a pinch clamp. With a helper holding the funnel and a dishpan to catch any spill, pinch the tubing shut and fill the funnel with mercury. Then release the pressure of the rubber tubing and allow mercury to run slowly into the barometer tube, withdrawing the small tube as the mercury level rises. When the barometer tube is full, there will be no large air bubbles in the mercury.

After the tube is full, slip over it a two-hole rubber stopper having a right-angled exhaust tube in the other hole. Cap the barometer tube with an inch-long rubber tube and half-inch bit of glass rod. The barometer tube may now be inverted into the mercury reservoir, the cap pushed off, and the rubber stopper worked down to close the reservoir. The mercury column will now register changes in pressure when any device is connected to the exhaust tube.

If no exhaust plate is at hand, nail cleats across the ends of an $8'' \times 24''$ board, and cement an $8'' \times 8''$ square of good plate glass to the center of the board with hot sealing wax. (See Figure 2A.) Grind the end of a round or triangular file so that a three-sided pyramid with an approximate 60° apex is formed. Put a little turpentine in the center of the glass, and, holding the file point at about 45° with the glass, give it a twisting motion. As the hole deepens, bring the file nearer the vertical. Make the hole large enough for the shank of a $\frac{1}{4}$-inch T-tube, preferably of metal, which is pushed up through the board and glass plate and is hot-waxed in position.

With the exhaust barometer and the pump plate, it is possible to show that when air is taken from an enclosed space, the remaining air expands and has less pressure. Partially inflate a rubber balloon and place it under a bell jar on the exhaust plate. (See Figure 2E.) The bell jar must be vaselined to make it air-tight. Attach the exhaust barometer to one arm of the T-tube and an exhaust pump or a Bernoulli pump to the other. As air is pumped from the jar, the balloon inflates and the barometer goes down. When the hose is disconnected, air whistles in, the balloon deflates, and the barometer rises.

It is well to repeat the last part of this experiment with the

barometer tube pinch-clamped and the inlet tube held in some sawdust. The pupils can see that the inrushing air blows the sawdust before it. This may help rid the pupils of such expressions as, "A vacuum picks things up."

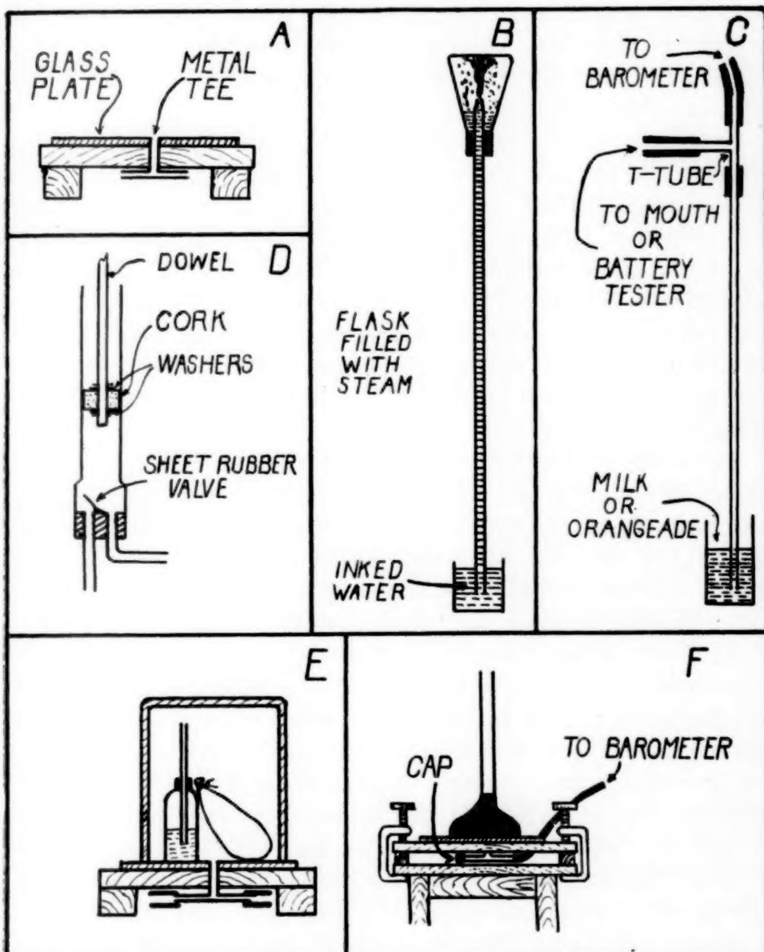


FIG. 2. Applications of the exhaust barometer.

If no balloons are available, one may use a similar demonstration. Push a glass tube through a one-hole stopper to the bottom of a small bottle half-full of colored water. (See Figure 2E.) Place this under the bell jar. When air is taken from the bell jar,

the air in the bottle expands and pushes the colored water into the tube.

Pupils can be shown that when an enclosed space increases, the pressure decreases. Use a bell jar with a one-hole stopper in the upper end and sheet rubber tied over the other end. Connect the exhaust barometer to a glass tube in the stopper and pull out on the sheet rubber. The decreased internal pressure is indicated by the falling barometer. This demonstration may be followed by the well-known lung experiment.

Next in order is the study of the drain plunger. The demonstration can be made impressive by clamping the exhaust plate to a common kitchen table and using a plunger with a six-inch diameter cup. (Figure 2F.) Connect the barometer to the exhaust plate and cap the other arm of the T-tube. Grease the edge of the cup and flatten it thoroughly on the plate gefore slipping it over the central hole. Ask a pupil to hold the barometer above the table. When the operator pulls up on the plunger, the space beneath it increases, the barometer drops, and the table rises from the floor.

The study of the water pump is in order. Make a model as shown in Figure 2D (or use a commercial model with a T-tube) and connect one of its tubes to the barometer, which should be kept above the level of the pump. Fill an Erlenmeyer flask or a milk bottle half-full of water and close it with a two-hole stopper through which leads a glass tube below the water level. Connect this tube to the second tube of the pump. If one pupil sucks on a tube connected to the other hole of the water container while another pupil pumps, no water will enter the pump even though the barometer falls. When air is let into the water container the pump operates, thus showing that the water is raised by air pressure, not by the suction. It also shows how misleading the term "suction" is when one has no knowledge of the mechanics of air.

What happens when you drink through a tube may also be shown with the barometer. Use a T-tube to connect the barometer to the drinking tube as in Figure 2C and keep the barometer above the level of the tee. Put milk or orangeade in a bottle and let the pupil drink through the tube. As his jaw drops, the space in his mouth increases, the barometer shows a drop in pressure and the liquid rises into his mouth. If a two-hole stopper is used in the bottle, one can demonstrate that the liquid will not rise when the other hole is closed even though the barometer indicates a drop in pressure.

The action of a medicine dropper can be demonstrated on a large scale by using a battery tester. The barometer is once again connected to the system with a T-tube. When the bulb is released, the barometer drops and liquid rises into the tube.

If your vacuum cleaner is built to take a hose, connect the barometer to a glass tube pushed through a stopper in the end of the hose. When the fan pushes air out of the case, the air remaining expands and has less pressure, as is indicated by the barometer.

The barometer may also show what happens in the canning process. This should be introduced by a steam experiment. Draw a nozzle on the end of a long glass tube and push the nozzle end through the large end of a one-hole stopper so that about four inches protrude beyond the small end as in Figure 2B. Put a teaspoon of water in an Erlenmeyer flask and put the stopper with the tube in it. Hold the flask with a pair of tongs and boil the water completely away. Invert the flask so that the tube is in a jar of water. As the flask cools the water rises in the tube and fills the flask. Repeat the experiment with a short glass nipple in place of the long tube. When the water is boiled away, attach the barometer to the short tube. When the flask cools almost all the mercury runs out of the barometer tube.

Boil some water in a stoppered flask and lead the steam through a rubber tube into a pint rubber-ringed fruit jar. Put a lighted splint into the jar to show that the air has been driven out. When the jar is quite hot, clamp the cover on and let it cool. Then unclamp it and let a pupil try to pull the cover off. The steam drove the air out of the jar and when the steam condensed, there was a partial vacuum in the jar so that the outside air held the cover on.

The condensation of steam in the Erlenmeyer flask tubed to the barometer also helps pupils to understand the famous collapsing syrup can experiment. Without this introduction it is difficult for them to understand that the condensation of the steam leaves a very high vacuum in the can.

NEW TYPE DRINKING GLASSES

Drinking glasses that look like ordinary glass tumblers are made from a heat-resistant resin molding powder. They are hard to break and are little affected by boiling in water. The same powder is used to make automobile and other lenses.

YOUR JOURNAL*

Glen W. Warner
Editor of School Science and Mathematics

School Science and Mathematics started with this aim, quoting from Vol. I, No. 1: "The object and aim of *School Science* is to give you all possible aid in your teaching. It will keep you posted on scientific matters having a more or less bearing on education. It will furnish you inspiration and information. *School Science* is to be by and for the science teacher. You are invited to send in articles, notes, news and suggestions,—anything that may be of value and interest to the teacher of science."

The first editorial staff consisted of the late C. E. Linebarger with twelve associates; a teacher college man in astronomy, a college man and a high school man in biology, a high school botany teacher, a high school teacher of chemistry, and a State Normal school chemistry man, a secondary school man in geography, a State Normal school man in geology, a private high school man in meteorology, a teacher of physiography from a girls' high school, and physics men from two city high schools. Some of the leading articles in the first number were "High School Astronomy" by George W. Myers, "Research Work for Physics Teachers" by E. L. Nicols of Cornell, "Quantitative Experiments in Chemistry for High School" by Lyman C. Newall, State Normal School, Lowell, Massachusetts, "A Neglected Feature in Fern Study" by J. A. Foberg, and "A Scioptican for the High School" at a total cost of $7.90 by C. W. Carman, University of Illinois. It was a successful journal from the start.

But good as it was it could not continue with a fundamental member missing. Two volumes only of *School Science* were published. Mathematics was necessary. First a mathematics supplement was published, two issues in volume III and three issues in volume IV. Volume V came out as School Science and Mathematics emphasizing the change, and has so remained to the present time.

Let us examine these early volumes of a new type journal for the American teacher. The first issue was of March 1901, 51 pages of copy, plus some advertising pages. Eight issues fol-

* Presented at the annual meeting of the Central Association of Science and Mathematics Teachers, November 27, 1943.

lowed averaging about 56 pages each plus advertising. No numbers were published for June, July and August. Volume II was quite similar but slightly larger averaging about 60 pages of articles per issue, but this volume started with March and ended with the following March, no numbers being published in June, July, August and September. Volume III ran from April 1903 to March 1904 inclusive, omitting July, August and September, averaging about 60 pages per issue. Three copies of the *Mathematical Supplement* were issued with Dr. G. W. Myers as mathematics editor and. C. E. Linebarger as managing editor. Volume IV contains only three issues of *School Science*, April, May and June, 60 pages of articles each, and two issues of the *Mathematical Supplement*, January and March 1904, about 40 pages each. In the fall of 1904 no issues of either appeared. I never talked with Mr. Linebarger about it, but Dr. Myers said quite frankly in my first conversation with him after becoming editor, "If you are willing to work over articles by others and let your own writing go, you will make an editor." I did not understand just what he meant then, but I soon learned.

In the fall of 1904 *School Science* and the *Mathematical Supplement* were missed. Charles H. Smith of Hyde Park High School and president of the new Central Association of Science and Mathematics Teachers did not like getting along without a journal. He had been one of the leaders in starting the Central Association of Physics Teachers and, before a year was up, in expanding it into the Central Association of Science and Mathematics Teachers. He wanted action and said to Chas. M. Turton, "Let's put out a journal." These two men went to work. Twenty interested teachers and business men agreed to put up $50 each the first year if needed. Mr. Smith and Mr. Turton put out the first issue of SCHOOL SCIENCE AND MATHEMATICS in January 1905 and followed it with eight healthy, interesting numbers, a total of 780 pages plus advertising for the year. No one of the sponsors was ever called upon for financial assistance. For a few years the journal just paid its bills with nothing left over for those who did the work. Every science meeting in the nearby states was visited. Smith and Turton were there with sample copies of SCHOOL SCIENCE AND MATHEMATICS.

Within a few years the influence of these two teachers was no longer bounded by Chicago limits. It extended from the Atlantic to the Pacific, throughout the United States and Canada.

Foreign exchanges were made and soon a few subscriptions from foreign countries began to come in. This continued until there were subscribers in every Province of Canada, many in Europe, and some in Asia. Then came the war. Europe never recovered from the first World War. At one time we received exchange journals from Great Britain, France, Germany, Holland, and India. SCHOOL SCIENCE AND MATHEMATICS was read there, because frequently an article was quoted and our methods were studied. Now several of these beleaguered and devastated cities have asked that copies be kept in store for them to be delivered when their countries have been set free and their children again allowed to live and grow up as free men and women. Some years ago I made up an order of almost a complete set of back numbers and shipped them to the University of Tokio. No doubt many people in Japan are anxiously waiting the time when they can again take their places in a world of justice and progress.

One day about twelve years ago I received a post card—one of the large foreign cards. I was not even sure of its source, but I took it to a friend, Dr. Chada, now at the Chicago Teachers College, then at Crane Junior College. He looked at it for some time, then read it to me. It was a most interesting short letter from the heart of Siberia, whose author was interested in what SCHOOL SCIENCE AND MATHEMATICS had to say on the teaching of science. Some of these things have kept me at it, not the little check I get regularly. That would all go to pay office help, had we not given up practically all social functions and church activities over seventeen years ago. Please note the "we," because had it not been for the very efficient clerical help by one whose name has never appeared on the journal, you would have had another editor many years ago. Only Great Britain and India now remain on the Old World exchange list but one from Buenos Aires is now regular. I hope our new business manager will see that sample copies go to *all* American universities not now regular subscribers.

Now let us see just what the editorial staff does. Their duties as editors consist in the main of two things: 1st, they are to become acquainted with other teachers in their respective fields, learn what they are producing and are capable of producing and get them to put it in shape for publication; 2nd, to look over contributed articles, reject or approve and make corrections. Many of the articles come to my office first, but many also are first sent to the departmental editors. In many cases I never see

the articles that are rejected by them. In some cases the departmental editor has done so much work on the article before it is ready for publication that he should be credited as a co-author. A third important activity of the departmental editor is to review books for his department or find other suitable reviewers. This activity is probably more important than we generally consider it to be. The librarian of a great university library told me that before ordering new books she made it a rule always to look over our book review list.

It is the editor's business to keep the journal well apportioned; to allot space to the various departments; to see that each department is represented by the type of material in demand; to become acquainted with the new movements in all the sciences; to cultivate the acquaintance of the book and apparatus companies and their representatives because their products are our tools. Moreover they make such a journal possible. The editor's records tell him the type of articles that will be available for the next issues. He must be the judge of what to publish and when to publish it. In this type of journal we cannot publish articles in the exact order of their receipt. At times we may have a half dozen articles accepted in mathematics, let us say, and only one in chemistry. Then if new chemistry articles come in, and we try to get them, they will be published before some of those on hand in mathematics. That is why it sometimes occurs that an article must wait a long time before publication while others are published immediately. Often articles have been invited but we cannot predict just when they will be ready. When such an article reaches us we give it as early publication as possible, even though a number of others in the same department have been accepted in the meantime and are waiting publication. That is also the reason why departmental editors cannot promise the exact date of publication at the time an article is approved. We have more than one editor for each department and one may send in several approved articles while the other approves none.

After the material has been accepted it is my job to select the articles for each issue. This requires an estimate of the amount of space needed for each article—not always a real easy job when there are typewriters with various type sizes, margins that may be wide or narrow, tables of all sizes and types, figures, illustrations and references. But with a little practice quite accurate estimates are possible. For example, in the November

issue I published exactly the copy I sent to the printer, except that I needed to supply one filler of four lines in length and another of two lines. The articles used varied in length from one of less than a page to one of seventeen pages. Of course this was partially just luck because I never can be quite sure just how much space the Problem Department will require since I never see this until it is in type. But our June issue must turn out about that way because a new contract is signed in the summer and we cannot be sure that we will have the same printer in the fall. And that is a job in which the business manager is the deciding factor. However, in the past my opinion has always been sought and your business manager has always listened attentively and effectively to any complaints or comments I have made.

After the galley proof has been prepared the journal is then made up at my office. If the printer has been on time, and if contributors return their proof promptly, then we have time to make up the dummy from corrected galley and can take the time necessary to go over it without hurrying. But that seldom happens. In a recent issue corrected proof reached me from Canada several days before that from a nearby city. In recent months, instead of getting galley proof from the printer the tenth of the month, it sometimes reaches me as late as the twenty-third. In such a case what can be done about an article that came from California or Washington. Articles from Alaska or Panama we send in a month ahead and a year ago such authors knew better than to send it by regular mail. It came by airmail above the dangers of submarines. If the author's corrected proof does not reach me, I must check the proof carefully from the original copy and hope the author will not change his mind. But it often happens that our judgment is bad here. Only a few years ago a university man read a paper at one of our annual meetings. It was recommended highly by the chairman of the section. We prepared it for publication and sent it to our printer. No corrected proof came from the author; we made up the dummy and sent it to our printer. A few days later along came the corrected proof from his office less than two hundred miles away, and he had really changed the article. I then wrote him that his article had been sent to the printer as he had originally written it but that I would make the changes indicated, if space would permit, when correcting the page proof. This would of course be done at our expense. But the corrections

called for a half page additional space and I did not remember whether a filler was required at the close of his article or if it had just about filled the page. After writing this answer I was out of the city for three or four days attending a science meeting in the east. He wired the printer, the business manager, and the editor, all *collect*, that the changes must be made or his article could not be published. No one was at my office to pay for the message, hence I never received it. SCHOOL SCIENCE AND MATHEMATICS paid for the other two. When the page proof came I removed a half-page filler at the end of his article, changed the wording slightly, and made most of the changes indicated. It then just filled the available space and I guess he was quite happy. The costs were paid by your journal. If he had taken the time to put his article in shape for publication before the convention, it would have saved his nervous system, and a few bits for the journal.

Probably I have said enough to give you some idea of the joys of an editor. I have said nothing about the hundreds of letters I write answering questions about articles published in previous years or those someone thinks SCHOOL SCIENCE AND MATHEMATICS has published. I have not mentioned the information I have given as to where data can be found for the term paper or master's thesis. I have said nothing about the articles we have rejected, some very good ones but not suitable for this type of journal, nor the comments received from a few authors of rejected articles. I have learned when judging an article only to ask this: To how many people will this article be of particular benefit in teaching young people science? If the answer is "many," the article is accepted and we do not ask who he is who wrote it. Some of our best articles have come with some such note as this: "Here is a device I have found effective in teaching this principle. If you think it worth publishing, your journal will reach those who can use it. Otherwise just drop it in your waste basket." Some very good articles come from beginning teachers or from the teacher in some small high school out in the sticks; some come from the great men in our universities who find time to think about how to teach science.

I have not told you much about the history of your journal. In a few minutes this cannot be done. But when I visit a great university where young people are preparing to teach, whether it be in the great cities of the east or in the western country of magnificent distances, I find the students and teachers of science

reading and discussing what you have written. Your journal is not a local paper read by only a few in your own community. What you publish here is read in distant lands and in future years. Your successful class-room devices and teaching stunts will be adopted and used by others. As a teacher of basic science you cannot afford to teach only those students who attend your classes. You should plan to get your best things in your journal where they will live after you are gone and travel to distant lands and future times. You do things just a little bit different from anyone else. In fact some of these little differences are the very things that make you successful. Make a careful examination of your teaching devices and tell others about them through your journal. Such articles are always read and the devices tried by many.

CHILDREN FIGHT PRODUCTIVE WAR

"It is not generally realized to what extent this nation is fighting its productive war on the labor of children."

This is opinion of Wage and Hour Administrator Metcalfe Walling, U. S. Labor Department. Speaking before the recent convention of the American Federation of Labor, Administrator Walling said:

"I believe it is my further duty to call your attention to one other serious situation which must, of necessity, concern you all. This is the vast increase in the number of children who are being employed in American industries. I think it is not generaly realized to what an extent this nation is fighting its productive war on the labor of children . . . .

"About one million more boys and girls of 14 to 17 years of age were at work in April of this year than would have been employed except for the war . . . . The number of employment and age certificates issued for boys and girls of 14 to 17 has practically doubled annually from 1940 to the present time. Although at first we tended to draw largely on the 16 and 17 year olds we are now dipping down into the 14 and 15 year olds. There has been ain over-all increase of 31% of boys and girls to whom Social Security numbers have been issued for the first quarter of 1943 as compared with the same period in 1940.

"As would be expected, there has been a tremendous increase in the number of minors illegally employed . . . The number of establishments found in violation of the child labor provisions of the Fair Labor Standards Act increased 33% over 1942 and 197% over 1941. Of the 4,567 minors illegally employed in 1943, 18% were under 14 years of age and 58% were 14 or 15 years old, leaving only 24% of the relatively older minors illegally employed who were 16 or 17 but still were in hazardous occupations . . . .

"At the present time, of course, we are less concerned about the threat to the older worker and the stability of family income which child labor normally presents, but we cannot ignore the fact that stunted minds and stunted bodies are being fostered and that educational opportunities for our young people are being ignored. Not only do we want strong bodies in our future America but also we want good citizens who had been educated to a sense of their civic responsibilities and who have been given the tools with which to carry out those responsibilities. We cannot look with complacency on what is happening to our young people."

ARCHIMEDES AND MATHEMATICS

H. T. Davis
Northwestern University, Evanston, Illinois

(*Concluded from February*)

Archimedes Launches a Ship

Since the imagination of these present, even the astronomers, is quite dazzled by these immense figures, the conversation soon shifts to other matters.

"Tell us about your launching of the great ship which I saw in the harbor today," says the prince, entering the conversation for the first time. "For I have heard that you contrived to do alone the task that many men would do for us."

"That matter was much simpler than you would think," says Archimedes, "for I made use only of the principle of the lever. Thus you see how neatly this spoon balances upon my finger although the bowl is much heavier than the handle. The matter came about rather curiously, however, for one day when I was discussing this problem with King Hiero, in the heat of explaining the great power of the lever, I made the rash statement that, given a place to stand upon, I could even lift the earth itself. But King Hiero, who always has his eye on the practical, told me that while he could not furnish me another earth with which to try my powers, there was a large ship in the harbor that wanted launching and perhaps I might try my skill on it. You see that I was craftily caught."

"Archimedes is too modest to tell the end of the story," says Conon, "but I know it well and perhaps it would be best for me to finish it. Our learned and skillful guest thereupon set up a multitude of ropes in the shipyard, compounding many times the force of the simple lever. He then invited a large number of people to board the vessel and instructed the workers to fill it with its customary freight. Thereupon, seated at a distance, he manipulated his pulleys and the great ship glided smoothly into the water.

At this recital of Conon there is great applause from the guests and the king instructs his son to make a note of these devices for use in the shipyards in Alexandria.

The Story of King Hiero's Crown, and Other Matters

"Tell us another thing," says the king. "Occasionally the

officers of the treasury have difficulty in knowing whether a quantity of gold coins may not be debased by silver or other metal. But I hear that this problem was once proposed to you by King Hiero, and that you gave him the solution of it."

"That was, indeed, a distracting matter," says Archimedes smiling. "And unfortunately the solution to it came to me in my bath. They tell me that I ran out into the public square without my clothes, crying that I had discovered the key to the riddle. But be that as it may, the principle is one of great interest and usefulness and may be stated as follows: A solid which is heavier than a fluid will, if placed in it, descend to the bottom of the fluid, and the solid will, when weighed in the fluid, be lighter than its true weight by the weight of the fluid displaced. And so you see, I weighed the crown in water and then in air, and compared these weights with those of known quantities of pure gold and silver."

Now Eudemus, the anatomist, spoke up. "Tell us, Archimedes, have you ever reflected upon the nature of light by which we see?" he asks. "Those of us who strive to penetrate the nature of the human body need better eyes. For much there is of interest that lies beyond the strength of our vision."

"I am writing a treatise on this subject now," replies Archimedes, "but what we yet know is little enough. Light moves in straight lines as everyone knows, and if we curve a mirror ever so little and uniformly, then these rays can be brought into focus at a single point. I am now contriving a device which may be useful in arts of war to set on fire the ships of enemies."

At this the king shows immediate interest. "Tell us, Archimedes, what do you think of the new methods which our mutual friend Ctesibius is devising to apply these natural forces in the discharge of stones and arrows?"

"I must confess," replies Archimedes somewhat boldly, "as I have often told King Hiero, that my own interest lies in the reasons behind these practical devices, rather than in the machines themselves. A geometrical figure in the sand has much more charm for me than all the engines on the battlements of the city. But I shall gladly describe some of the machines which we are contriving against our enemies, should ever they decide to attack us. They involve the same principles as those now used by your own Ctesibius."

And thereupon Archimedes proceeds to discourse for a while upon the many devices which he had in mind should an enemy

attempt the beleaguerment of Syracuse. Many years after the time of the dinner which we are describing Marcellus, the Roman general, besieged the city of Archimedes. Since a lively account of this famous siege has been given by Plutarch, who derived his information from the earlier *Histories* of Polybius, we can do no better than to let him describe the consequences:[3]

When, therefore, the Romans assaulted them by sea and land, the Syracusans were striken dumb with terror; they thought that nothing could withstand so furious an onset by such forces. But Archimedes began to ply his engines, and shot against the land forces of the assailants all sorts of missiles and immense masses of stones, which came down with incredible din and speed; nothing whatever would ward off their weight, but they knocked down in heaps those who stood in their way, and threw their ranks into confusion. At the same time huge beams were suddenly projected over the ships from the walls, which sank some of them with great weights plunging down from on high; others were seized at the prow by iron claws, or beaks like the beaks of cranes, drawn straight up into the air, and then plunged stern foremost into the depths, or were turned round and round by means of enginery within the city, and dashed upon the steep cliffs that jutted out beneath the wall of the city, with great destruction of the fighting men on board, who perished in the wrecks. . . .

Then, in a council of war, it was decided to come up under the walls while it was still night, if they could; for the ropes which Archimedes used in his engines, since they imparted great impetus to the missiles cast, would, they thought, send them flying over their heads, but would be ineffective at close quarters, where there was no space for the cast. Archimedes, however, as it seemed, had long before prepared for such an emergency engines with a range adapted to any intervals and missiles of short flight, and through many small and contiguous openings in the wall short-range engines called scorpions could be brought to bear on objects close at hand without being seen by the enemy.

When, therefore, the Romans came up under the walls, thinking themselves unnoticed, once more they encountered a great storm of missiles; huge stones came tumbling down upon them almost perpendicularly, and the wall shot out arrows at them from every point; they therefore retired. And here again, when they were some distance off, missiles darted forth and fell upon them as they were going away, and there was a great slaughter among them; many of their ships, too, were dashed together, and they could not retaliate in any way upon their foes. For Archimedes had built most of his engines close behind the wall, and the Romans seemed to be fighting against the gods, now that countless mischiefs were poured upon them from an invisible source.

However, Marcellus made his escape, and jesting with his own artificers and engineers, said, "Let us stop fighting against this geometrical Briareus, who uses our ships like cups to ladle water from the sea, and has whipped and driven off in disgrace our sambuca (a bridge of ships called *sambuca* from some resemblance to the musical instrument of that name), and with the many missiles which he shoots against us all at once, outdoes the hundred-handed monsters of mythology."

For in reality all the rest of the Syracusans were but a body for the designs of Archimedes, and his the one soul moving and managing everything; for all other weapons lay idle, and his alone were then employed by

[3] *Life of Marcellus*, xv–xvii.

the city both in offense and defense. At last the Romans became so fearful that, whenever they saw a bit of rope or a stick of timber projecting a little over the wall, "There it is," they cried, "Archimedes is training some engines upon us," and turned their backs and fled. Seeing this, Marcellus desisted from all fighting and assault, and thenceforth depended upon a long siege.

At the end of his account of the siege of Syracuse Polybius makes the following pertinent comment: "Such a great and marvelous thing does the genius of one man show itself to be when properly applied to certain matters. The Romans at least, strong as they were both by sea and land, had every hope of capturing the town at once if one old man of Syracuse were removed."

Many other ingenious mechanical devices were invented by Archimedes. One of these was the water screw, which was used widely in Egypt for irrigating the fields. According to a description given by Vitruvius, this machine consisted of a screw with spiral channels "like those of a snail shell," which revolved within a wooden pipe. It was operated by man-power, but did not raise the water as high as the water-wheel.

Apparently, also, the first planetarium was constructed by Archimedes and exhibited in Syracuse. It was taken by Marcellus as his only share of the booty in the sack of the city. The following description of it is given by Cicero in his *De Republica* on the authority of Gallus, a Roman consul in the year 166 B.C.:

All the more remarkable, therefore, was the discovery of Archimedes, since he had devised a method of construction whereby, extremely different though the movements of the planets are, the mere turning of the globe would keep them all in their unequal and different orbits. When Gallus rotated the globe, the moon really followed the sun on the bronze globe by the same number of revolutions as are the days it lags behind in the sky. Thus it happened that on the globe there occurred a solar eclipse, just like the real eclipse; and also that the moon passed into that tract of space covered by the earth's shadow when the sun (and the moon were on opposite sides of the earth).

The Invention of the Method of the Calculus

When the king had finished plying Archimedes with questions about the character of war engines which he was then devising, Conon again speaks up. "I hear, Archimedes, that you have invented a new method for answering many perplexing questions in geometry," he says. "Perhaps you might be able to tell us something of these matters."

"I hesitate somewhat to do this," answers Archimedes, "for

my method goes beyond the canons of the ancient geometers. Thus I am forced to assume that a geometrical figure can be sliced up, as it were, into an infinite number of lines, which, when added together, make up the whole piece. I then add together all these lines and hence attain the entire figure; but my mathematical friends here may object with much truth that no man can really sum these separate lines and get thereby the area of the original geometrical figure."

"The idea is certainly a novel one," admits Dositheus, "and would surely not be allowed by the strict rules of our traditional geometry."

"However, the results appear to be indistinguishable from the truth," says Archimedes, "and I have used the method in a number of cases. The theorems thus obtained, however, I have endeavored to prove by the accepted logic in such matters. Perhaps I can illustrate it in the case of a parabola."

"And what, may I ask, is a parabola?" inquires the king.

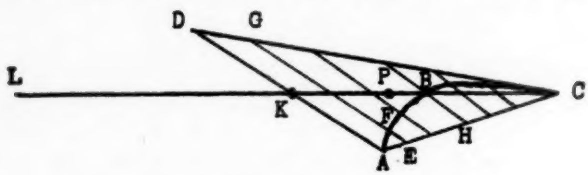
"A parabola," Archimedes replies, "is one of the conic sections. Euclid, of revered memory, wrote four interesting books about these useful figures, but they are worthy of much deeper study. Thus, if we take any right circular cone and cut it by a plane, we shall obtain a geometrical figure which belongs to this family of curves. If the plane is parallel to the base, we clearly have a circle, but if the plane intersects at an angle, we shall have, for one direction, a closed figure like an oval, and for another, an open figure with lines extending to infinity. If the plane cuts the cone in a line parallel to the axis, then we shall have what we are pleased to call a parabola."

Although Archimedes and some of the mathematicians before him were familiar with the conic sections and had developed many of their properties, the authoritative work on the subject was produced by Apollonius of Perga in a treatise in eight books called the *Conics*. As a result of this work, Apollonius was given the name of the Great Geometer, by which he is deservedly known to all succeeding generations of mathematicians. Apollonius belongs to the history of Alexandria, for he flourished in the Museum during the reigns of Ptolemy Euergetes I (247–221 B.C.) and Ptolemy Philopater (221–203 B.C.). At the time of the banquet which we are describing Apollonius was about twelve years old, for it is conjectured that he was born about 262 B.C. This date is assumed because he dedicated the fourth and following books of his treatise on conic sections

to King Attalus I of Pergamum (241–197 B.C.) and was thus probably about twenty-five years younger than Archimedes.

In order to make the matter more comprehensible to the king, Archimedes now takes a pear from a dish of fruit on the table and makes a section with a knife which cuts the pear parallel to its stem. A very presentable parabola is thus made visible.

"And now, if we enclose the segment of the parabola (*AFBC*) in a triangle (*ADC*) one side of which (*DC*) is a tangent and the



Quadrature of the parabola

other (*AD*) is parallel to the axis (*BH*) of the parabola," remarks Archimedes, placing the section of the pear upon the table and indicating the lines with two thin strips of bread, "and if we fix a lever thus (*LC*), with its fulcrum on the far side of the triangle (*K*), midway between its ends, then in very truth the segment of the parabola, placed at the far end of the lever (*L*) will just exactly balance the triangle. And, finally, since the lever-arm of the triangle (*KP*) is just one-third the length of the other end of the lever (*KL*), I know at once that the area of the parabola is one-third the area of the triangle."

There are cries of astonishment from the mathematicians at this novel theorem and the others know that they are hearing the solution of a remarkable problem, although it is quite beyond their comprehension.

"Describe to us, Archimedes, the method which you used to find this beautiful result," requests Dositheus, his eyes alight with excitement. "There is nothing in Euclid that can give us the clew."

"I fear to tell you this," replies Archimedes, "for it lies beyond the ordinary laws of geometry. But what I do is to weigh each separate line of the parabola against the corresponding line of the triangle (that is to say, *EF* against *EG*), and then I add them up, since the area of the parabola must be the sum of all its lines."

At this there is dead silence in the room, the mathematicians

looking at one another in amazed surprise. For here, in this banquet of the king, these scientists of long ago faced for the first time in the history of man the noble concepts of what has come to be called in modern times the infinitesimal calculus. No wonder the bright light blinded them as it did the eyes of men twenty centuries later when Sir Isaac Newton and Gottfried Leibniz rediscovered the principles of the calculus. It is true that Archimedes had not introduced the notion of an infinitesimal, for he thought in terms of lines instead of strips which had small increments for their bases, but many a long year was required to formulate these ideas in a manner acceptable to the rigor demanded by modern mathematicians.

Archimedes is plied with other questions about his great discovery and even those unfamiliar with mathematics catch something of the excitement of the method as the distinguished guest describes how he has applied his theory to obtaining the volumes of various solids. These were, for example, such figures as the sphere, the cone, the paraboloid and hyperboloid of revolution, and oblate and prolate spheroids.

The Spiral of Archimedes

Perhaps the most amazing result of all these astonishing achievements of Archimedes, however, was his investigation of the properties of spirals, which he later published in a treatise entitled *On Spirals*. In the introduction to this work, which he dedicated to Dositheus, Archimedes makes the following interesting statement:

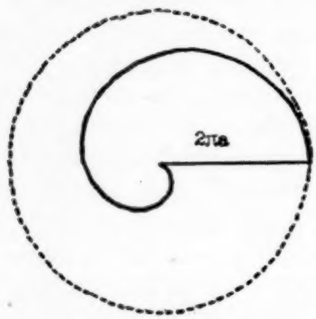
> Of most of the theorems which I sent to Conon, and of which you ask me from time to time to send you the proofs, the demonstrations are already before you in the books brought to you by Heracleides; and some more are also contained in that which I now send you. Do not be surprised at my taking a considerable time before publishing these proofs. This has been owing to my desire to communicate them first to persons engaged in mathematical studies and anxious to investigate them. In fact, how many theorems in geometry which have seemed at first impracticable are in time successfully worked out!
>
> Now Conon died before he had sufficient time to investigate the theorems referred to; otherwise he would have discovered and made manifest all these things, and would have enriched geometry by many other discoveries besides. For I know well that it was no common ability that he brought to bear on mathematics, and that his industry was extraordinary.

The curve which has come to be called the spiral of Archimedes is described by its inventor as follows:

> If a straight line drawn in a plane revolve at a uniform rate about one extremity which remains fixed and return to the position from which it

started, and if, at the same time as the line revolves, a point move at a uniform rate along the straight line beginning from the extremity which remains fixed, the point will describe a ***spiral*** in the plane.

Perhaps the greatest achievement of Archimedes, and certainly one of the most astonishing results attained by the great mathematical school at Alexandria was his computation of the



The spiral of Archimedes ($\rho = a\theta$)

area enclosed by one loop of the spiral. Or as Archimedes put it: "The area bounded by the first turn of the spiral and the initial line is equal to one-third of the first circle," that is to say, $\frac{1}{3}\pi(2\pi a)^2$.

But the hour is now late and although many matters might still be proposed to prolong the conversation, it becomes obvious that the old king is weary. Reluctantly we drink our parting cup of wine, take leave of our generous host and his son, the prince, and accompanied by servants with torches to light our path, we make our way into the cool night air. And as we seek our quarters, we reflect once more upon the glories of that ancient city of Egypt and upon the hope that lies for man in the achievements of its Museum.

The End of the Story

The story of Archimedes has long been known to the world and what he did has been written imperishably upon the records of science. It is to the glory of rulers that they honored him and his memory. Even his death which occurred in 212 B.C. during the sack of Syracuse has become a sacred legend of science. The story is told by Plutarch as follows:

But what most of all afflicted Marcellus was the death of Archimedes. For it chanced that he was by himself, working out some problem with the

aid of a diagram, and having fixed his thoughts and his eyes as well upon the matter of his study, he was not aware of the incursion of the Romans or of the capture of the city. Suddenly a soldier came upon him and ordered him to go with him to Marcellus. This Archimedes refused to do until he had worked out his problem and established his demonstration, whereupon the soldier flew into a passion, drew his sword, and dispatched him.

Others, however, say that the Roman came upon him with drawn sword threatening to kill him at once, and that Archimedes, when he saw him, earnestly besought him to wait a little while, that he might not leave the result he was seeking incomplete and without demonstration; but the soldier paid no heed to him and made an end to him. There is also a third story, that as Archimedes was carrying to Marcellus some of his mathematical instruments, such as sun-dials and spheres and quadrants, by means of which he made the magnitude of the sun appreciable to the eye some soldiers fell in with him, and thinking he was carrying gold in the box, slew him. However, it is generally agreed that Marcellus was afflicted at his death, and turned away from his slayer as from a polluted person, and sought out the kindred of Archimedes and paid them honor.

HOW ELEMENTARY SCIENCE CAN HELP CHILDREN WITH THEIR WARTIME NEEDS

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The topic of *Children's Needs* is, indeed, a very old one and has been discussed and debated many times before with rather definite results. However, during the two years since Pearl Harbor the whole situation has been changed and it is obvious that we need to reconsider them on a wartime basis.

It seems to me that before considering how we can help to meet these needs with elementary science that we should first examine them to see what they are, and then attempt to fit them into an elementary science program. Many recent discussions have pointed out this need and that need in wartime, but there have been just a few instances that we have examined the changes in children's lives that are going on, and definitely list them point by point. It seems to me that one of the best list of changes has been the one that has been made from the study of the elementary school teachers of the District of Columbia which was published in *Educational Leadership*. According to this study, based mostly on collective opinion, the wartime changes going on in children's lives are as follows:

1. Children are left more on their own.
2. Children do more of the family buying because working mothers have little time to go to the stores.

3. More children are buying lunches rather than bringing them from home.
4. Children have more money. Much of it is spent. Some of it is spent in purchasing war stamps and war bonds.
5. Children are better cared for physically. Their clothing is better and they seem to be getting good, nourishing food.
6. More work is being done by children; some children have more responsibilities at home.
7. Children whose brothers or fathers are away fighting appear to be worried.
8. Children play with more simple toys. Many children are making their own toys.
9. They are buying more milk at school. They are still buying candy bars.
10. Most children seem to be more careful with school supplies such as paper, pencils, crayons, etc. They seem to be less wasteful.
11. Many children are working at remunerative jobs such as selling papers or working in stores or at home after school.

Now, if we analyze these statements, no doubt we will not agree that these are situations in all communities. Regrettable or otherwise, some communities are more war conscious than others. This is true of the East when compared with the Middle West and consequently we have to consider these changes in children's lives in importance according to the community. However, considering these items in their general meaning they could be sorted into four general divisions that can be easily related to elementary science. We could say then, that the changes going on in children's lives could be classified as related to the fields of 1, Responsibilities; 2, Health; 3, Mental Hygiene; and 4, Relative Values. We will briefly consider each one.

(1) *Responsibilities.* Among the responsibilities that more children are taking include buying lunches, going to and from school, more and varied activities of action and thought, and more self-supervision and less adult supervision, and many other responsibilities and changes that are obvious. In the elementary science curriculum if more stress is put on food, clothing, safety, purchasing, and understanding of home utilities, there would be little question that the elementary science program is meeting the new wartime needs of children as well as increase their helpfulness in the home. A few minutes additional thought on this point will reveal to all of you many other ways in which elementary science could help children handle these additional responsibilities and take on even more.

(2) *Health.* There has been no time in the history of our country that as many thousands of people have been aware of the health problem as are aware of it today. The results of the selec-

tive service physical examinations have denfitely convinced America that there should be many thousands less "4-f's" in the next generation than there are today. But these are not for future wars, no, for future peace. I don't feel that we can lay too strong emphasis on the importance of the elementary science program stressing health and teaching our young people to improve or maintain their health. Teaching health is not just talking about it or "appreciating" it but teaching its importance and maintenance. Outdoor science certainly helps in this respect, —yes, physiology, elementary first aid, and a general knowledge of ourselves on the basis of our natural age-level comprehension. Colds, thousands of them every year, might be avoided if we could effectively teach to children and adults alike that best information that is known about colds today. We all know the problem of the over-heated homes in America, the over-dressed children, and those who are not permitted to play outdoors. There are thousands of these situations in every large city. We only have to go to any public gathering whether it is a motion picture show, an educational meeting, an elevator in the finest hotel to realize that we have to "dodge" coughs, turn away from people who talk and breathe in our faces, and avoid circumstances that tend to help the spread of colds and other diseases.

(3) *Mental Hygiene.* As has already been observed, especially in the East and Far West, our children are greatly concerned about the welfare of the country and, of course, all our young people are concerned about their fathers, brothers, and sisters in the Service. It is necessary for children to face these realities but they should face them with the proper frame of mind. This means that they should have a feeling of faith and security and in elementary science subjects some of this needed faith and security can be given to children. Certain phases of astronomy, nature study, and knowledge of living creatures can go a long way. Only science teachers who themselves have this feeling of faith and security and a more abstract view of science along with the practical are qualified for these phases of children's needs. This is a topic that can stand considerable thought and would take more time than we have available at this meeting.

(4) *Relative Values.* The fourth and last of the categories of children's wartime needs that we will mention today is the development and use of the sense of relative values. With the extra money many children have, will it be used for good food, bad food, good candy, or bad candy? Will the money be used to

purchase war savings stamps or for expensive and useless toys? Will it be a "Tommy" gun or something more substantial for the child's development? Yes, we may think that these implications sound a little too theoretical but the fascinating games of "Guadacanal," "Bataan," and others named for their war significance can be ruled out by simple means. The "ack, ack, ack" that fires the imagination of small children can be replaced by science and other activities that stimulates that same imagination and calls forth the same energy in more constructive ways.

The opportunity for teaching elementary science that will help to develop a sense of relative values has never been greater. Though the specific relative values of this and of that may not carry on through life, nevertheless, children can be taught to at least pause to consider relative values before choices are made. If a teacher is successful in this endeavor she has made considerable headway.

In conclusion we have, in my opinion, a most unusual opportunity to do better teaching in science than in past years. This teaching should not be in straight subject matter, not in just "appreciation," but in the areas of science that will help children meet their present-day needs in 1), Responsibilities; 2), Health; 3), Mental Hygiene, and 4), Relative Values.

NEW ELECTRONIC INSTRUMENT TESTS SMALL-CALIBER SHELLS

An "electronic ear," to match the well-known "electric eye," is now used in ordnance plants to test the shells for the deadly little 20-millimeter automatic cannon which some of our fighter planes carry and with which the secondary armaments of our warships bristle.

"Sonotest" is the convenience-name that has been given to the device, which tells whether or not shells are sound, and therefore safe to load and use, by the way they ring when dropped on an anvil. It is a variant of the old shop-keeper's trick of tossing coins on the counter to hear whether they "ring true"; as a matter of fact, that was the purpose for which it was first devised.

Properly made shells, without cracks and with their copper rotating bands well seated, will have a certain vibration frequency, or range of tone. Also, perfect shells will ring longer than cracked or misbanded ones. The sound is picked up by a microphone, and the resulting electrical oscillations fed through a hook-up of electronic tubes. Suitable relays light green "go" lights if the shell is good, and warn the operator to discard imperfect specimens.

Each shell is tested twice: once by dropping it on its bottom, again by dropping it on its side. With a little preliminary training, a girl operator can test from 1,200 to 1,800 shells an hour.

THE JUNIOR HIGH SCHOOL SCIENCE PROGRAM

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There is a present day tendency to raise questions concerning the maintenance of the status quo in education. That this is true is evident from the current number of speeches and articles pertaining to the schools and the war effort in which there is often the implication that the schools have failed in their task of educating boys and girls with no accompanying suggestions as to how their education can be improved. This paper follows the trend, at least in part. There is no desire to condemn the junior high school science program but rather to direct attention to its changing position in the program of general education. In the light of this changing position it is possible to suggest certain desirable modifications in the typical junior highschool science curriculum.

It is essential that we agree on certain historical aspects of junior high science. There should be no disagreement on the approximate period of the growth of general science. Between the years of 1910 and 1935 the per cent of schools offering general science increased from approximately four to eighty-five. In this same period, with the establishment of junior high schools, there was a spread downward into the seventh and eighth grades.

There is a greater possibility of disagreement on the reasons for the introduction of general science in the public schools. As often stated these are: First, the large number of pupils who dropped out of school, especially in the ninth grade. It seemed that a cirruculum based on college requirements and not on the needs of pupils was in part responsible for this mortality. Second, there was a need for an orientation course that helped to bridge the gap between elementary school nature study and the specialized senior high courses of biology, physics and chemistry. Third, there was a loss of enrollment in the sciences of the secondary school at a time when the value of science in life was becoming increasingly more obvious. Teachers recognized the need for a science course that considered children's interests and that would lend itself to the psychological approach in teaching.

Probably because of these factors there were several committee reports that emphasized the need for changes in our science curriculum. In 1912, the Central Association of Science and

Mathematics Teachers appointed a committee to study the question of "A Unified High School Science Course." They recommended that, "The first year of science in the high school should be organized upon a broad basis involving fundamental principles of the various sciences and using materials from all, if needed."

The committee evidently was aware of the difficulties and inadequacies of presenting highly specialized science courses to all pupils. Opposition to their recommendation was strong but there was enough acceptance of their philosophy for science courses that the N. E. A. appointed a committee which was known as the Commission on Reorganization of Secondary Education. The Commission's sub-committee on Reorganization of Science in Secondary Schools[1] recommended the sequence of science courses and the course content that is in general use today. This included a recommendation that general sciences go down to the seventh and eighth grades in the junior high school.

In 1930 the National Society for the Study of Education appointed a committee of six persons to study the science program. The result of their intensive study is Part I of the Thirty-First Yearbook. It definitely recommends a coherent and cumulative twelve year program of science instruction and includes specific recommendations for junior high science.

If we can agree on these factors as some that were important in the birth and rise of general science, an objective examination of the present pattern in junior high science is more nearly possible. Textbook analyses are indicative of the units now offered in junior high science. From these analyses we know that there is little agreement as to the grade level in which a given unit should be placed but that there is general agreement on the inclusion of certain units in the junior high curriculum. Typical examples of such units are Fire, Heat and Energy, Machines, Water, Light, Control of Living Things, Weather and Climate, Food of Plants and Animals, Electricity and Magnetism, Astronomy, Rocks and Soil, Health, and Improving Living Things. With these titles and a knowledge of typical general science courses any of us could outline a modern course of study for one year or for three years. It is of interest to note the evidence of content changes between the years of 1917–

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[1] Caldwell, O. W. and Committee, "Reorganization of Science in Secondary Schools," U. S. Bureau of Education, Bulletin 26, 1920.

1936, as shown in Table I which was prepared by Turner[2] to compare his own analysis of general science content, as indicated by textbooks, with earlier analyses.

TABLE I. AVERAGE PERCENTAGE OF SPACE DEVOTED TO EACH MAJOR TOPIC IN EACH OF THE FOUR ANALYSES

I Ten books analyzed by H. A. Webb.[3] (1917)
II Eight books analyzed by Marie Miller.[4] (1921)
III Seven books analyzed by Robert Miller.[5] (1924)
IV Six books analyzed by P. M. Turner. (1936)

Topics	I	II	III	IV
Animals	2.6%	1.5%	2.9%	3.0%
Astronomy	2.2	3.1	1.9	5.2
Chemistry	8.1	4.1	11.2	9.6
Economics	0.6	2.6		2.0
Food	3.3	2.4	5.3	3.9
Household Applications	4.1	5.1	8.8	4.6
Meteorology	7.1	5.4	0.8	2.3
Physics	29.6	37.7	29.5	35.1
Physiography	11.3	10.0	15.7	14.7
Physiology	11.5	14.0	12.1	13.4
Plant Life	10.4	10.6	8.7	5.1
Textiles	1.6	0.4		1.0

It is clear that there are no marked changes in the per cent of total page space devoted to the topics listed in the table in the twenty year period considered. This fact can be rationalized from two quite opposite points of view. First, it may be interpreted as evidence that general science texts of 1917 solved the educational shortcomings for which the course was originally included and therefore little change was necessary in following texts. Second, it may be interpreted as evidence that general science texts up to the time of Turner's study did not keep pace with the changes in our educational program that occurred since 1917. Texts written since 1936 have undoubtedly changed to some extent. However, a similar analyses of current texts would probably reveal only minor changes in course content.

If the first interpretation is accepted, there is no need to proceed with a discussion of the junior high science program. Since the second interpretation is plausible only if we recognize im-

[2] Turner, P. M., "Trends in the Selection of General Science Subject Matter Determined by an Analysis of 1936 Textbooks and a Comparison With the Results of Earlier Analyses." Master's Thesis (unpublished). State University of Iowa, 1937.

[3] Webb, H. A., "A Quantitative Analysis of General Science," SCHOOL SCIENCE AND MATHEMATICS, 17: 534–545, 1917.

[4] Miller, M. C., "Study of General Science," Master's Thesis (unpublished), State University of Iowa, 1921.

[5] Miller, R. J., "General Science Textbooks," Master's Thesis (unpublished), State University of Iowa, 1924.

portant changes in education, it is advantageous to review the original reasons for the introduction of general science and the subsequent factors that affect these reasons for teaching general science.

As previously listed, pupil mortality was used as one good argument for introducing general science. However, in 1941, over the country at large, at least 70 out of 100 young people of secondary school age were actually in attendance. In some communities there were as many as 90 out of 100. Unless one is willing to conclude that this increase in school population was caused by the introduction of general science, one must conclude that pupil mortality is no longer as good an argument for the teaching of junior high science as it was thirty years ago. This fact places general science on a plane more nearly equivalent to that of any other science course in the general education pattern.

The gap between elementary school nature study and the specialized sciences of the senior high school has been narrowed considerably by the growth of elementary school science. Careful examination of existing elementary science courses of study or textbooks reveals an array of units that compare very favorably to the typical junior high school science units. One may go so far as to say that if the general science of thirty years ago helped to bridge the gap then the elementary science of today removes the gap.

What modification should result from the fact that elementary school science is becoming firmly established? Since it would be impossible to answer this question in detail without a careful discussion of typical elementary school science courses of study the reader is referred to Gilbert's[6] article. This article contains three tables which show the topics of the greatest frequency of occurrence in thirty elementary school science courses of study.

Those teachers who are familiar with our present day junior high science will immediately recognize the fact that there is little evidence in these courses which indicates recognition of the elementary school material. Some repetition is defensible in terms of learning. However, many of us who teach junior high school have had motivational problems primarily because our pupils feel that they have already studied the units that we try to develop. Those who have not had the experience need only

[6] Gilbert, A. E., "Science Content in the Elementary School," SCHOOL SCIENCE AND MATHEMATICS, 43:769–773. 1943.

to examine some of the science books intended for intermediate grades and compare them with typical junior high school texts. If the writers of junior high science curricula will revise their units in terms of this elementary school background which is becoming more and more prevalent, our science program as a whole will be improved.

We are now left with one of the original arguments favoring general science. *Educators recognized the need for a science course that considered children's interests and that would lend itself to the psychological approach in teaching.* This need still exists and in spite of the help from elementary school science teaching is, in my opinion, the best modern argument favoring junior high science. If predictions concerning the post-war world are at all accurate the preceding comments will not need modification. We can expect to have at least as high a percentage of pupils of junior high age in school as there were in 1941. We can also expect large numbers of students to stay in school through college because of the possibility of federal aid. Therefore we can continue to think in terms of a continuous science program for a majority of the persons of school age.

It seems then that the three years of junior high science should be devoted to using and expanding the science materials gained in the elementary school. Pupil background in science should be recognized as should the fact that many pupils continue in school beyond the ninth grade.

One possible method of procedure is to correlate junior high science with social studies. That this is not a revolutionary idea is evident from the following paragraphs taken from an article written by Johnson.[7] "You may be teaching two subjects in successive periods. You may even have the same pupils in both classes. In that case you can plan for a double period in a fused subject . . . " or "you may desire to plan a project with one or more other teachers. This project may involve a few weeks' co-operative planning and working. Topics such as the following reveal many possibilities for cooperative work between science and social studies teachers: The History of Science, The History of Inventions, Communication Yesterday and Today, Transportation Yesterday and Today, Science and Modern Warfare, Technological Unemployment, Public Utilities, Housing, Soil Conservation, Game Laws, Advertising, Crop Control, Sanitary

[7] Johnson, Philip G., "The Sciences Need the Social Studies," SCHOOL SCIENCE AND MATHEMATICS 40: 708–715, 1940.

Codes, Health Regulations, Photography in American History, Cooperatives, Health Insurance, Hospitalization, and a host of other topics."

Just how far Johnson would be willing to go in his cooperation is a question I cannot answer. The textbook series for which he served as editor does not contain evidence of much correlation with the social studies. I can, however, state that we have done some experimental work in correlating junior high science and social studies units in the Experimental School at the State University of Iowa. It was the consensus of opinion of those involved that it would be possible for teachers whose chief interest lay in either science or social studies to teach these correlated units. In our development of the content there were always two teachers involved, one from science and one from social studies. We hoped to be able to prepare enough teaching materials to make it possible for one teacher regardless of his field of major interest to take over the combined fields. War and the resulting personnel problems have forced us to revert to traditional junior high science. We do expect to continue our experimental combination when the teaching staff again becomes stabilized. As a result of our experience with a correlated science and social studies course for the junior high school we are convinced that the idea is sound. We prefer the selection of a "theme" for the year. For example, we used "Men and Machines" as a seventh grade theme and had little difficulty in developing science and social studies content. Also, as a result of our experience we would propose units as indicated by the following brief outlines

I. How man has developed on the earth.
   A. The geologic time eras
   B. Early man
   C. The materials used by early man
   D. The civilization of the ancient Egyptians
   E. How climate, soil, and other geographic factors affected the life of the ancient Egyptians
   F. The machines used by the ancient Egyptians
   G. How men lived, worked and made war during the Middle Ages.
II. The forms of energy that have replaced the slaves of ancient civilization
   A. The kinds of energy
   B. Using the potential energy of fuels to run machines
   C. Obtaining and using electrical energy.

It is only fair to call attention to a few disadvantages of such a correlated program.

1. Since subject matter lines are not maintained, schools with

subject matter departments can expect clashes of "personalities" from social studies and science.

2. Such a course will almost invariably tend to become a reading and discussion course with a minimum emphasis on experimental problem solving.
3. Study materials that develop both the science and social studies viewpoints are hard to find and often unobtainable.
4. Pupils will learn fewer scientific facts during the junior high years.

As was stated earlier this idea of closer correlation with the social studies is not offered as unique nor original. It is emphasized here because of the fact that the original reasons for teaching junior high science have been modified by the growth of science in the elementary school and by the changes in the general education pattern.

SELF INDUCTION

F. W. Moody
Cleveland High School, St. Louis, Missouri

Here are two handy little hook-ups on a single mounting, utilizing a low resistance choke coil, *I*, and a low resistance transformer, *T*, salvaged from a box of radio material and requiring no battery for operation.

* * * *

Direct current is lead to coil *I* through a 20 ohm heating unit, in series with the resistance *R*, of such length as to produce about 8 volts across its terminals. Through contact key *K*, coil *I* and lamp *L*, a twelve volt lamp of the Christmas tree type, are both thrown in parallel with *R*. With the current flowing in *R*, when key *K* is closed, lamp *L* glows moderately but when the key is released the lamp flashes brightly for a moment due to the self induction action of the coil in sending stored energy to the lamp.

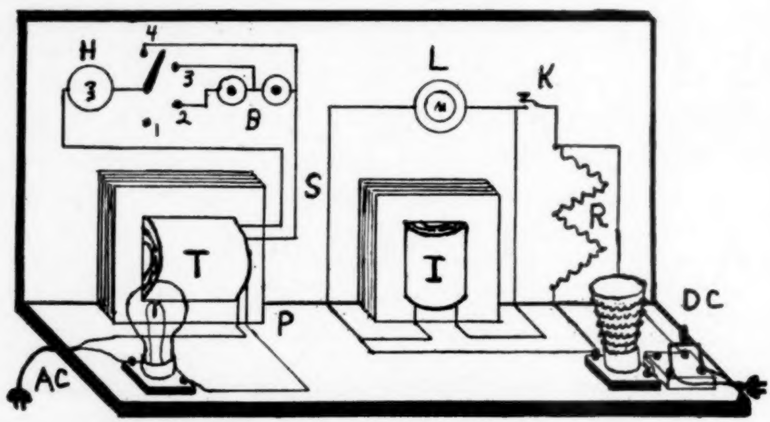
* * * *

The transformer has a 60 watt lamp in the circuit of the larger primary but when the line cord is plugged in to a 110 volt A.C. source this lamp shows no evidence of any current passing as long as the secondary switch is at the open circuit position, 1. When turned to position 2, contact is made through the two

coils, *B*, in series, and also in series with lamp *H*, a six volt lamp from the headlight of an automobile with a carrying capacity up to three amperes.

The coils, *B*, taken from a doorbell, have considerable inductance and with the switch in position 2 permit lamp *H* to glow only very dimly. The 60 watt lamp in the primary likewise glows dimly giving indication of a small current in the primary.

With the switch turned to position 3, one of the *B* coils is cut out and as *H* brightens so also does the lamp in the primary



Apparatus to show self induction.

circuit. As the current in the secondary increases more current comes through the primary. At position 4 with both *B* coils cut out, *H* glows brightly. The 60 watt lamp also shows almost its normal brightness. The whole thing can be brought out and shown in about five minutes and saves a lot of time in trying to put over these ideas in other ways.

NEW PLASTIC MADE FROM CHEAP GAS

A new, highly versatile plastic, named polythene, has been developed by Du Pont chemists and is now ready for the market in commercial quantities—provided necessary allocations for war purposes can be shown by the processor. It is stated to possess physical qualities that will make it useful in such peacetime employments as toothpaste tubes, wire insulation, waterproof coatings, piping and adhesives. In thin sheets it is flexible without being limp and rubbery, while in thicker shapes it is still enough to be classified as a rigid plastic.

Polythene is made by the polymerization, or chemical welding, of large numbers of ethylene molecules. Ethylene is a gas derived from petroleum, natural gas and coal, hence is a cheap, easily obtainable raw material.

VALENCE IN THE LIGHT OF ELECTRONIC STRUCTURE

C. W. Bennett
Western Illinois State Teachers College, Macomb, Illinois

Many attempts have been made to reconcile classical valence with other modern electronic conceptions. Some have rejected the classical valence concept entirely while others are loath to give up a tool which has proved so valuable in the past.

According to our present modern ideas, valence may be divided into at least two distinct types: ionic and covalent. These are roughly distinguished by the facts that in ionic valence, electrons originally belonging to one atom have been transferred completely to another. The former atom now has a positive charge due to the electrical unbalance resulting from a loss of (negatively charged) electrons while the latter atom becomes negative due to a gain of negative charges. The two charged atoms are called ions and are held together at least in the crystal form by the mutual attraction of oppositely charged bodies. The second type or covalence consists of two atoms sharing a pair of electrons, one of which is contributed by each of the atoms. There is no positive or negative here except that the electrons are negative while the atomic kernels are positive. A true double or triple bond consists of two or three pairs of shared electrons. In an interesting variety of the second type, dative covalence, a pair of electrons contributed by one atom is shared by it and another atom which contributed no electrons hence the name *dative* (Latin-giving). Each of these types will be discussed in detail below.

Ionic Valence

Ionic valence most resembles classical valence; which, no doubt, accounts for the apparent success of the old methods, since so many compounds used were ionic. Other names used for ionic valence are electrovalence and polar valence. This type of union occurs only in ionic compounds such as Na^+Cl^- $H_3O^+Cl^-$, Na^+OH^-, etc.

A simple cation is formed from a metal by the loss of its valence electrons. Simple anions are formed from non-metals by the gain of enough electrons to make the number of valence electrons equal to that of the nearest rare gas. The ions thus attain

the rare gas structure by gaining or losing electrons. The first twenty elements (up to and including calcium)[1] if they form simple ions at all, have only one ionic valence. Elements which have only one electron to lose, like sodium, or only one to gain, like chlorine, are very active while elements of the second and sixth groups involving two electrons are not so active. Elements of the third and fifth groups are much less active since three electrons are involved.

Carbon and silicon of Group IV and boron of Group III rarely, if ever, form simple ions. While nitrogen and phosphorus may form simple ions, they can not exist in the presence of water but are instantly hydrolysed as are oxide (O^{--}) ions and probably Al^{+++}.[2]

The elements of Group Ia (Li, Na, K, Rb, Cs) form only monovalent simple cations and those of Group IIa (Ca, Sr, Ba, Ra) as well as those of Group IIb except mercury (Be, Mg, Zn, Cd) form only divalent simple cations. The members of Group VIb (O, S, Se, Te) form only divalent simple anions while those of Group VIIb (F, Cl, Br, I) form only monovalent simple anions. With the exceptions of the non-metals just discussed, there are no others which form simple anions but there are many other metals which do form simple cations.

Elements Which Form Two or More Simple Ions

These may be divided into several types:

(1) Hydrogen. This simplest element presents a unique situation since it is just between a neutron and the element helium in structure. It may attain the "rare gas" structure of a neutron by losing the one electron, thus becoming H^+, or it may gain another electron and become H^-, like helium but with a negative charge. The H^+ or proton is now believed incapable of independent existence and immediately associates itself with water, ammonia or other solvent to become H_3O^+, NH_4^+, etc. This will be discussed below under dative covalence. The hydride ion (H^-) is halogenoid in character and forms true salts such as Li^+H^- which conducts electricity in the fused state, the hydrogen going to the anode like chlorine. These hydrides are, however, rapidly hydrolysed by water to give $Li^+OH^- + H_2$.

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[1] Except hydrogen. See below.

[2] A growing number of authorities believe all ions with charges higher than 2 are hydrolysed, and that all are hydrated in water; the exact formula of an ion in water is difficult to determine. The same holds for other solvents in which one would say the ion has been solvolized and solvated.

(2) The double ions, such as mercurous, Hg_2^{++}, and peroxide, O_2^{--}. Mercury forms the mercuric ion Hg^{++} by the loss of the two valence electrons it has. The mercurous ion, Hg_2^{++}, is formed by the sharing of one electron by each mercury and the loss of the other two (one from each). The peroxide ions are formed by two oxygen atoms joined by a covalent pair of electrons. This leaves a divalent negative charge on the ion.

(3) The transition elements. They have the property of moving electrons out from the next to the outside shell into the valence shell or allowing one or more to drop back. Those elements near the center of the long periods do not attempt to attain the rare gas structure but rather the "pseudo-rare gas" structure which may have from 8 to 18 electrons depending upon the location of the element in the period. Chromium, an element known to have several valences, has an electronic structure of
K L M N
2, 8, (8), (6) or almost any other arrangement of the two outer shells so that the M shell never has less than 8 electrons and the total for M and N is 14. The common ions of chromium are the very active chromous (Cr^{++}) 2, 8, 12, (2), the last two being lost to attain the pseudo-rare gas structure, and the chromic ion (Cr^{+++}) 2, 8, 11, (3), with the three lost. There is some doubt of the independent existence of Cr^{+++} in water. It may be CrO^{+}, $Cr(H_2O)_6^{+++}$, or some other such ion.[2] Its interesting colors are due to the various coordinations which it undergoes. In such ions as CrO_4^{--}, $Cr_2O_7^{--}$, etc. the chromium 2, 8, 8, (6) is not a simple ion and does not lose six electrons to form Cr^{++++++} but shares the six with oxygen. This will be discussed under dative covalence more fully. Manganese, another variable element, similarly has 15 electrons in the outer two shells allowing various combinations such as 2, 8, 8, 7 as in MnO_4^{-}, 2, 8, 9, 6 as in MnO_4^{--}, 2, 8, 11, 4 as in MnO_2, 2, 8, 12, (3) as in Mn^{+++} and 2, 8, 13, (2) as in Mn^{++} where 3 and 2 electrons are lost, respectively. (The existence of Mn^{+++} as such is open to challenge, however.)

Iron and cobalt may form ions of $+2$ and $+3$ charge similarly but only rarely as in the iron cyanide complexes, etc. (see below) are they part of an anion where they share electrons like manganese or chromium. Nickel may have 2 or 4 valence electrons so that it usually forms the Ni^{++} ion but occasionally quadrivalent compounds. Copper forms cupric (Cu^{++}) ions by the loss of the 2 electrons from 2, 8, 17, (2) or cuprous ions, Cu^{+}, by the

loss of the 1 electron from 2, 8, 18, (1). It is to be noted that all these ions except[3] Cu^+ are colored.[4] This is thought to be due to the incomplete 18 pseudo-rare gas structure which is not present in Cu^+ and Zn^{++} 2, 8, 18, (2) and the remainder of that period. The fourth type of variable ionic charge is caused by the fact that two of the electrons in any shell are closer than the others to the nucleus. The total number of electrons or all but the innermost two may be used. Examples are tin and lead which have as common valence $+2$ although they have four valence electrons. Lead does form compounds where the classical valence is $+4$ such as PbO_3^{--}, PbO_2, and $Pb(C_2H_5)_4$ but forms no simple tetravalent cation such as Pb^{++++}. Stannic tin, frequently written Sn^{++++}, is probably part of an anion such as $SnCl_6^{--}$, SnO_3^{--}, or SnO_2 and never as the simple cation. Similarly, bismuth, arsenic, and antimony have valences of $+3$ or may form ions with $+3$ charge instead of the $+5$ as required by the five valence electrons. The classical valence for the bismuthate ion, BiO_3^-, makes bismuth pentavalent but Bi^{+++++} ion does not exist and the so called bismuthate ion is questioned.[5] The pentavalent arsenic and antimony chlorides are not simply $AsCl_5$ and $SbCl_5$ but probably exist as the $AsCl_6^-$ and $SbCl_6^-$ ions, respectively. It will be seen from these illustrations that the existence of any simple cations as such with a charge more than two is doubtful. The carelessly formulated higher valent ions of some authors are actually part of ions such as $SnCl_6^{--}$, $CuCl_4^{--}$, AlO_2^-, $Al(OH)_2^+$, AsO^+, etc.

Such ions as Cu^{++}, Zn^{++} and probably all other cations are really solvated in solution to form complexes, $Cu(H_2O)_4^{++}$, $Zn(NH_3)_4^{++}$, etc. which will be discussed later.

Covalence

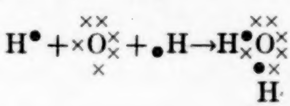
Covalence, also called non-polar, homopolar, or non-ionic valence, consists, as mentioned above, in the sharing of a pair of electrons contributed by the two atoms equally. There is no justification for assigning plus or minus charges to either of the atoms in this union. It is true that the kernels of the atoms are, of necessity, positive so that all of the atoms could be thought

[3] Several authorities believe the cuprous ion to be a double one like Hg_2^{++}, but such a structure is not required by theory for copper, since it is a transition element.

[4] Color is associated with coordination. Even anhydrous Cu^{++} is colorless which see below.

[5] Middleton and Willard, *Semi-micro Qualitative Analysis*. Prentice-Hall, Inc., New York, 1943, page 135. This text also gives an excellent discussion of ion and complex ion colors.

of as positive and the electrons negative. The basis of this type of union is the attaining of the rare gas structure by sharing electrons. The two as required for helium or the 8 as required for other rare gases belong in part to each atom and are not transferred completely away from one atom to another. Elements which form such unions are those which have a considerable hold on their electrons. The alkali metals and the alkaline earths probably never form such compounds. Hydrogen, as we have seen, forms H^+ and H^- as well as covalent unions in which its one valence electron becomes part of a pair shared with another atom. Oxygen, nitrogen, carbon, and the halogens are probably the other most common elements in such unions. Each atom brings its set of valence electrons and will combine with enough atoms of another element to make each have the number required for the nearest rare gas structure. Thus oxygen with six valence electrons needs two more to make the eight required for the rare gas neon. Two hydrogens, each bringing one electron, will be required to complete the 8.



Oxygen now has 8 electrons and each hydrogen two as required for helium, but four claimed by the oxygen are also claimed by the two hydrogens, resulting in a firm union.

The pair of electrons in some combinations may be displaced toward one or the other of the sharing atoms so that a covalent union might begin to approach an electrovalence in effect.

Many more recent authorities especially Linus Pauling[6] have shown the importance of resonance in determining the properties of a given substance. Resonance is a phenomenon which occurs where two or more electronic arrangements are possible and which can mutually change into one another. A compound exhibiting this phenomenon will in general be more stable than its classical structure would indicate. Pauling has shown that most compounds contain several structures at once all of which contribute to the total effect and has even calculated, in many cases, the fraction which exists in each structure as indicated by the properties.

A coherent group of atoms where each has brought its full

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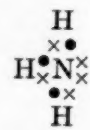
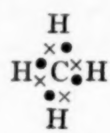
[6] Pauling, Linus, *Nature of the Chemical Bond.* Cornell University Press, 1939.

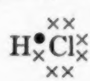
quota of electrons is a neutral molecule. If one or more electrons are missing, the group is a cation. If extra electrons are present, the group is an anion. In the case of nitrogen with five valence electrons, three hydrogens are required to complete the eight so that NH_3 is formed:



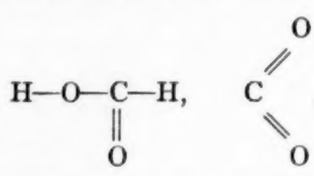
It will be noted that the classical valence of nitrogen is -3 as in the nitride (N^{---}) ion but there is really no negative charge on the nitrogen in ammonia. Carbon with 4 valence electrons requires 4 hydrogens to give CH_4:



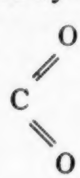
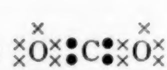
The halogens such as chlorine with 7 valence electrons require the addition of only one hydrogen (to give HCl).



The classical "double bonds" of some compounds such as



etc.[7] are formed by the sharing of two pairs of electrons.

 then is  and

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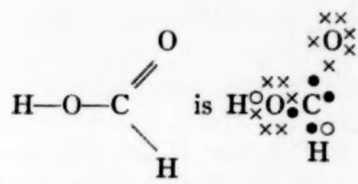
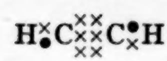
[7] But not $\mathrm{H{-}O{-}\overset{\overset{O}{\|}}{\underset{\underset{O}{\|}}{S}}{-}OH}$ etc., which are really dative covalent bonds. See below.

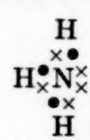


Triple bonds similarly consist of three pairs of shared electrons. Acetylene, C_2H_2 or H—C≡C—H, has the electronic structure

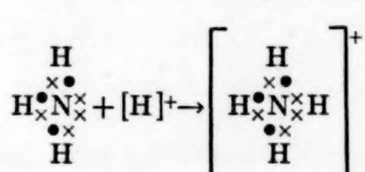


Dative Covalence

Dative covalence is exemplified by the so called co-ordination or Werner compounds and others. Werner explained compounds such as hydrates and ammonia complex ions by assuming that many elements have primary valence which follows the ordinary rules of valence and a secondary or residual valence which permitted them to add other complete compounds. It is now evident that such compounds are really formed because one ion, atom, or molecule has one or more pairs of unshared electrons which may be shared by another atom or other chemical entity which needs this pair to complete its valence shell. The simplest case is doubtless that of the ammonium ion, NH_4^+. As brought out above nitrogen, having 5 valence electrons, requires 3 hydrogen atoms each with one electron to give the complete shell of 8:



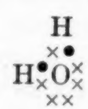
The resulting group, NH_3, is a neutral molecule because there is no excess or deficiency of electrons. It is evident, however, that the pair of electrons here shown on the right are unshared, but might be shared with a hydrogen ion (proton), entering with no electrons.



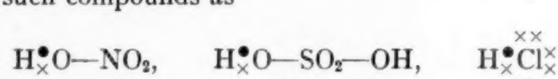
It will be noticed that the entering H^+ is now indistinguishable

from the other three since all electrons are identical and the dots and ×'s have been used here to show the *origin* only of the electrons. The resulting NH_4^+ has the positive charge because one nitrogen should have 5 electrons, and 4 hydrogens, one each, making a total of nine instead of the eight shown in the diagram. The deficiency of one electron gives, not the new hydrogen, but the whole group a charge of $+1$ so that the latter becomes a positive ion. Why does this NH_4^+ have a charge when CH_4 with identical electronic arrangement is a neutral molecule? Because carbon brings only four valence electrons and must combine with four hydrogen atoms each with its electron so that there is no excess or deficiency of electrons. Of course the nucleus of the carbon atom (atomic number 6) bears a charge of $+6$ while that of nitrogen (atomic number 7) in NH_4^+ is $+7$. Since the number of electrons is the same, NH_4^+ has one more plus charge than CH_4.

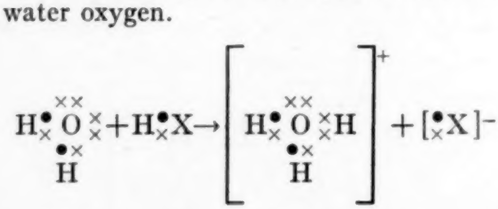
The hydronium ion, H_3O^+, is also a simple case of dative covalency. The water molecule may be expressed as



and will be seen to have two pairs of unshared electrons. Strongly negative groups such as $—NO_2$, $—SO_2—$, —Cl and the like tend to pull electrons held in a covalent union toward their part of the molecule, thus producing a strain. The hydrogen atom in such compounds as



and many others readily leaves (as the hydrogen ion) the molecule where it is under tension and attaches itself to one of the pairs of a water oxygen.



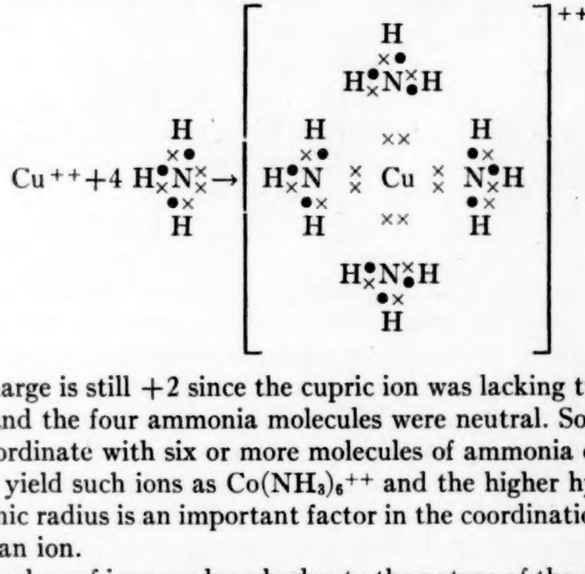
The deficiency of one electron in the H_3O^+ grouping makes it into a positive ion. There is still a pair of unshared electrons in the H_3O^+ but the positive charge now more or less repels an-

other hydrogen ion so that it is unlikely that the two hydrogen ions would be accepted even if there were not many more water molecules available. Weak acids such as acetic acid,

$$\mathrm{H}{}^{\bullet}_{\times}\mathrm{O{-}CO{-}CH_3},$$

do not possess a strongly negative group so that there is little tension on the potential hydrogen ion and only a few molecules lose them to form hydronium ions. The stepwise substitution, however, of chlorine atoms for the hydrogens results in a corresponding strengthening of the acid due to the electron affinity of the chlorine. For example, $HOCOCCl_3$ is a strong acid like HCl.

Hydrates and ammonia complex ions as well as many similar types are explained on this basis. For example, the cuprammonium ion, $Cu(NH_3)_4{}^{++}$, is formed by the cupric ion (Cu^{++}) without any valence electron, sharing the extra pair of valence electrons contributed by four molecules of ammonia:

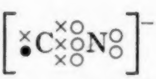


The charge is still $+2$ since the cupric ion was lacking two electrons and the four ammonia molecules were neutral. Some ions can coordinate with six or more molecules of ammonia or water and so yield such ions as $Co(NH_3)_6{}^{++}$ and the higher hydrates. The ionic radius is an important factor in the coordination number of an ion.

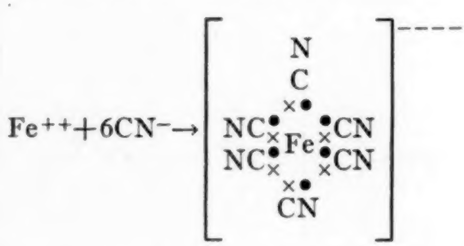
The colors of ions are largely due to the nature of the complex ion formations present. Cu^{++} (anhydrous) is colorless, while $Cu(H_2O)_4{}^{++}$ is bluish green although a strongly acid solution is more yellowish due probably to a complex ion like $Cu(H_2O)_3Cl^{+}$. Solid anhydrous $CuBr_2$ is practically black and was formerly thought to be un-ionized until dissolved in water when it passes through a brown to yellow to green to blue showing (so it was

said) progressive ionization. It is no doubt, however, a phenomenon of hydration, all the stages being completely ionized. The $CuBr_2$ probably contains colorless Cu^{++} and dark $CuBr_4^{--}$ ions. The yellow and green are variously hydrated ions such as $Cu(H_2O)_3Br^+$, etc., while the final blue is the familiar $Cu(H_2O)_4^{++}$. The addition of HCl or HBr does not "suppress the ionization" but instead dehydrates the complex ion hydrates. See footnote 5.

Such ions as the ferrocyanide, $Fe\ (CN)_6^{----}$, and ferricyanide, $Fe(CN)_6^{---}$, are easily explained here too[8] by dative co-valence. A ferrous ion, Fe^{++}, which has a deficiency of two electrons and which now has no valence electrons, accepts six cyanide (CN^-) ions



each of which shares its extra pair of electrons with the ferrous ion.



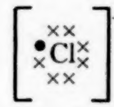
The charge of -4 on the ion arises from the deficiency of two electrons from the iron and the excess of six in the cyanide ion to give a total excess of four electrons which means a charge of -4. In a similar way the ferricyanide is made from Fe^{+++} and six CN^- ions where the excess is only 3 and the charge is -3.

An important type of dative covalence is commonly called semipolar union.[9] Here the acceptor arrives with full complement of electrons. Such unions are found in the oxygen acids of the halogens, sulfur, nitrogen, phosphorus, etc., but usually not those of carbon which are straight co-valent compounds. Examples are $HClO_4$, $HClO_3$, $HClO_2$, H_2SO_4, H_2SO_3, HNO_3, H_3PO_4, etc. These can be more simply discussed as the corresponding anion. The chloride in Cl^- has its own seven electrons

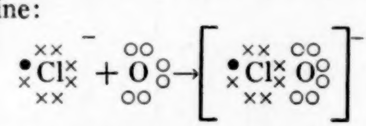
[8] Davidson, *Journal Chemical Education*, 14: 238 and 277 (1937).

[9] Sugden, "Parachor, Semipolar Bonds," *Journal Chemical Society*, 125: 1177 (1924). Sidgwick, "Co-ordination Compounds," *Chemistry and Industry*, 46: 799–807 (1927).

and one from an outside source



It is at once evident that there are four pairs of electrons which might be shared in dative covalence fashion with some other atom or group arriving with six electrons. A neutral atom of oxygen (which would be an oxidizing agent) arriving with its six electrons could finish out the eight by a dative covalence with the chlorine:



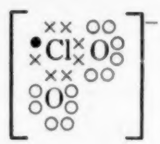
The new ion is the hypochlorite (ClO^-). Now in the un-ionized hypochlorous acid where is the H bound? Is it H–O–Cl or H–Cl–O? This is probably of no importance since there are six pairs of unshared electrons in the ion and any one pair might be shared by the hydrogen with the chlorine or oxygen. No doubt the molecule resonates from one to the other and consists of a mixture of both.

This ion has usually been formulated on the classical basis as $-O-Cl^-$ or else $-Cl{=}O^-$. A semipolar union is, however, not a true double bond as in organic compounds but is half non-polar or covalent and half polar (hence *semi-polar*) since the chlorine and oxygen are united by a pair of electrons (non-polar) but the chlorine has attained a positive charge by giving away an electron (half of the shared pair) while the oxygen has a negative charge due to its gain of one half of the pair of dative covalent electrons. We find then that the chlorine atom has a negative charge (polar) because it has an extra electron from an outside source and also a positive charge (semipolar) because it is sharing its one pair of electrons while the oxygen has a negative (semipolar) charge. Two negatives and one positive give a total for the ion of -1. Semipolar unions are commonly formulated with an arrow pointing from the donor to the acceptor and are used in place of the incorrect double bonds of classical notation. Hypochlorous acid[10] would be $H-O\leftarrow Cl$ or $H-Cl\rightarrow O$.

The addition of another neutral oxygen atom results in the

[10] A single bond means a pair of shared electrons.

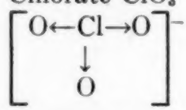
formation of the chlorite ClO_2^- ion:



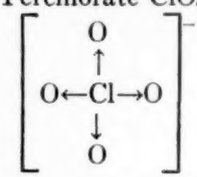
or $[O \leftarrow Cl \rightarrow O]^-$

with two semipolar unions. Similarly the chlorate ion and the perchlorate ion are formulated:

Chlorate ClO_3^-

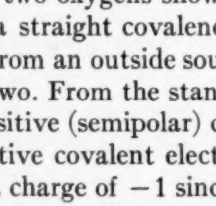


Perchlorate ClO_4^-

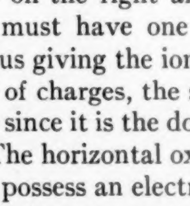


An interesting point here is that all these oxychlorine ions and the chloride ion itself have the same charge. This is due to the fact that each ion has only one extra electron from an outside source. The addition of the oxygen did not change this situation. The acids of bromine and iodine are formulated in a manner similar to those of chlorine and do not need to be further discussed. Permanganates are similar in structure to perchlorates.

The sulfate ion contains two semipolar unions:



or



The other two oxygens shown here on the right and left were joined by a straight covalence and must have one extra electron each from an outside source, thus giving the ion a negative charge of two. From the standpoint of charges, the sulfur atom has two positive (semipolar) charges since it is the donor for two pairs of dative covalent electrons. The horizontal oxygens each also have a charge of -1 since they possess an electron from an outside source. It will be seen that the four oxygens are negative and the sulfur $+2$, so the total charge for the sulfate ion is -2. Now the four oxygens are really indistinguishable in the ion since they all share a pair of electrons and electrons are all alike but only different in origin. The classical formulation for sul-

furic acid,

$$\begin{array}{c} \mathrm{O} \\ \| \\ \mathrm{H{-}O{-}S{-}O{-}H,}^{11} \\ \| \\ \mathrm{O} \end{array}$$

is incorrect since it means in terms of electrons that sulfur shares six pairs instead of the required four. It should be formulated (in the un-ionized form) as

$$\begin{array}{c} \mathrm{O} \\ \uparrow \\ \mathrm{H{-}O{-}S{-}OH.} \\ \downarrow \\ \mathrm{O} \end{array}$$

The sulfite ion (SO_3^{--}) has only one semipolar union:

$$\left[\begin{array}{c} \mathrm{O{-}S{-}O} \\ \downarrow \\ \mathrm{O} \end{array}\right]^{--}$$

shown here between the sulfur, and the oxygen just below it. The moderately weak, unstable sulfurous acid could be written

$$\begin{array}{c} \mathrm{H{-}O{-}S{-}OH.} \\ \downarrow \\ \mathrm{O} \end{array}$$

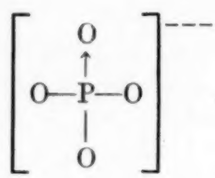
A possible isomer where one hydrogen is attached to sulfur has not been isolated due to the instability of the molecule, to the fact that ionization is a dynamic process and the hydrogens are constantly shifting, or to resonance between the forms.

The many other oxy-sulfur acids are of similar formulation but in many cases some of the oxygens have been replaced by sulfur as in the thiosulfate ion ($S_2O_3^{--}$) or

$$\left[\begin{array}{c} \mathrm{O} \\ \uparrow \\ \mathrm{O{-}S{-}O} \\ \downarrow \\ \mathrm{S} \end{array}\right]^{--}$$

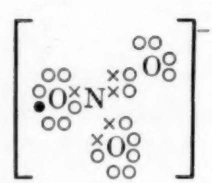
[11] But Pauling (note 6) insists that this structure makes some contribution.

In Group V of the periodic table, phosphorus is no doubt most typical. The orthophosphate ion (PO_4^{---}) is made up of one phosphorus atom which brought five valence electrons and three oxygens joined by simple covalence while one oxygen is joined by semipolar union:



The phosphate ion is rarely found as such but usually carries one hydrogen to give the HPO_4^{--} ion. The reason that the third hydrogen for H_3PO_4 is hard to ionize is that there is not so much attraction for electrons in an ion derived from an atom which needs three electrons to complete its shell. Thus the ionization grades as follows for the series: $HClO_4 > H_2SO_4 > H_3PO_4 > H_4SiO_4$.

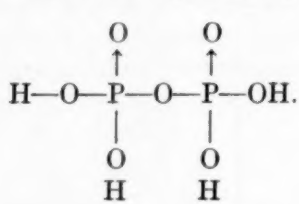
The nitrate ion



will be seen to have one simple co-valence, one semipolar valence and one double bond. All three oxygens resonate between its three forms. There are derivatives of the ortho nitric acid (H_3NO_4) known.

Nitrous acid, HNO_2, is formulated H–O–N=O.

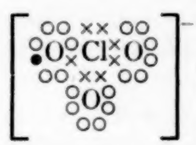
Some other acids of phosphorus represent molecules where residues of 2 ions are joined as pyrophosphoric acid, $H_4P_2O_7$,



The elements of Group IV, carbon and silicon, as would be predicted, form very weak acids which ordinarily contain no semipolar unions.

Valence Change

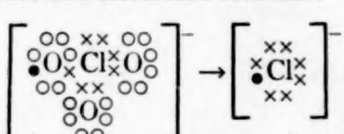
The valence-change method has been so successful in balancing equations that one is almost tempted to think that after all classical valence h d some actual basis. It is still considered by many[12] to be the only sensible way to balance equations where ions are not involved, although the ion-electron method[13] is probably best for those involving ions. Now when we consider that the classical valence of chlorine in $KClO_3$ is $+5$, what does that mean in terms of electrons? The electronic structure for the chlorate ion is



Now actually the ion as a unit has a charge of -1. The three oxygens are really identical after the ion is formed but two of the oxygens were held by a semi-polar union and one by simple covalence. The $+5$ is the result of a valence rule that all oxygens are charged -2 making a total of -6 for the 3 oxygens which must be neutralized by enough positive charges from the chlorine to have only one minus left over. This makes chlorine $+5$. Now defenders of the classical $+5$ say that it works, so it must be a real value. It may be pointed out, however, that if oxygen is always held to be -2, consistent values for other compounds must result. Consider a reaction where the chlorate ion is reduced to the chloride ion:

$$\overset{+5}{Cl}O_3^- \rightarrow \overset{-1}{Cl^-}.$$

It is seen by classical valence that $+5$Cl decreases to -1Cl or a loss of 6 valence points. It is agreed that for a loss in valence of one point a corresponding gain of one electron occurs. Some authors undiscriminatingly translate the 6 classical valence points lost by the chlorine into a gain of 6 electrons by the chlorine. Substitute the electronic formula:



[12] Bennett, C. W., *Journal Chemical Education*, 12: 189–192 (1935).

[13] Jette and La Mer, *Journal Chemical Education*, 4: 1021–1030 and 1158–1167 (1927).

It is at once evident that 8 electrons surround each chlorine; there is apparently no gain or loss of electrons so far as the chlorine itself is concerned. In the chlorate ion, however, chlorine is sharing electrons with 3 oxygens while all 8 belong to the chlorine in chloride. The ion electron method handles this situation easily. $ClO_3^- \rightarrow Cl^-$. In an acidic solution hydrogen ions are present (or H_3O^+ if one prefers).

$$ClO_3^- + 6H^+ \rightarrow Cl^- + 3H_2O.$$

It is now balanced atomically but not electrically. On the left the charges are $+6$ and -1 or $+5$ while on the right -1. Six electrons must then be added to the left to make -1 on each side:

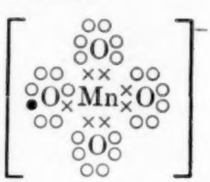
$$6\epsilon + ClO_3^- + 6H^+ \rightarrow Cl^- + 3H_2O.$$

This clearly shows that 6 electrons were taken up in the reaction but does not make the chlorine atom take them up. They are absorbed by the chlorate ion AND the hydrogen ions.

A still more complicated case arises in studying the reduction of the permanganate ion to the manganous ion:

$$\overset{+7}{Mn}O_4^- \rightarrow \overset{+2}{Mn}^{++}.$$

Classical valence decrees a loss of 5 points of valence which some would translate as a gain of 5 electrons *by the manganese*. Consider the electronic structure:



Here manganese has all its valence electrons, sharing with 3 oxygens in semipolar union and one oxygen in simple covalence. In the case of the manganous ion 5 of the 7 valence electrons have descended into the next inner shell since manganese is a transition element and the other two electrons have been lost making a charge of $+2$. Now the 5 electrons which found the inner shell are not lost at all but still belong to the manganese. It would seem that Mn in MnO_4^- has 8; in Mn^{++} none, so there would be a LOSS of 8 instead of gain of 5.[14] What

[14] At a superficial glance at the electronic structure but not actually.

does the ion-electron method show here? The reaction must take place in acidic reaction, i.e., presence of H^+ ions.

$$MnO_4^- + 8H^+ \rightarrow Mn^{++} + 4H_2O.$$

It is now balanced atomically but 5 electrons must be added to the left to balance it electrically.

$$5\epsilon + MnO_4^- + 8H^+ \rightarrow Mn^{++} + 4H_2O.$$

Five electrons are gained but not by *the manganese* alone. The permanganate ion in the presence of H^+ gained them.

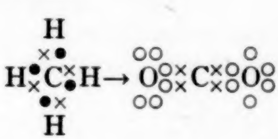
When metals become metallic ions, electrons are lost from the metal. $Zn^0 \rightarrow Zn^{++} + 2\epsilon$. Similarly when non-metals become anions, electrons are gained by the non-metal: $Cl^0 + \epsilon \rightarrow Cl^-$ but these are simple ions only.

When ferrous ion becomes ferric ion, one electron from the next inner orbit is drawn out and lost making a deficiency of one more electron. $Fe^{++} \rightarrow Fe^{+++} + \epsilon$.

Another interesting case is the burning of methane to carbon dioxide:

$$\overset{-4}{C}H_4 + 2O_2 \rightarrow \overset{+4}{C}O_2 + 2H_2O.$$

Classical valence decrees a gain of 8 valence points by the carbon. The electronic structure



shows eight electrons for each carbon which appears to be no gain or loss.

Such an equation cannot be balanced by the ion-electron method so it cannot answer our problem but 4 oxygen atoms with only 6 electrons each enter into oxides where they, by sharing, have 8 each or a gain of 2 electrons each, total 8. These were lost not by the carbon alone but by the methane molecule as a whole.

In the oxidation of sulfite ion to sulfate ion and similar reactions (nitrite to nitrate, chlorate to perchlorate, phosphite to phosphate, etc.) an atomic oxygen with its six valence electrons (or its equivalent) is added to a pair of unshared electrons belonging to the sulfur (or nitrogen or chlorine etc.)

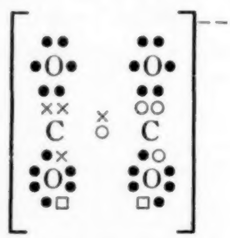
$$\overset{+4}{SO_3^{--}} + \overset{0}{O} \rightarrow \overset{+6}{SO_4^{--}}.$$

From the classical standpoint sulfur gains 2 points in valence but the formula shows the same number of electrons. Oxygen merely enters without bringing its share of electrons resulting in a loss for the *sulfite ion* of two unshared electrons.

In the oxidation of oxalate ion to carbon dioxide:

$$C_2O_4^{--} \rightarrow 2CO_2$$

there is only one significant change, the -2 charge is removed, showing a loss of 2 electrons or $C_2O_4^{--} \rightarrow 2CO_2 + 2\epsilon$.



The pair of electrons which joins the two carbons is lost and a resulting rearrangement leads to a double bond between each oxygen and carbon.

Thus it is seen that a knowledge of the electronic structure and its changes is helpful in any study involving valence.

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Science does not know its debt to imagination—Ralph Waldo Emerson.

IMPROVING THE EFFECTIVENESS OF LABORATORY WORK

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The common educational term, "growth in service," connotes primarily the improvement of one's ability to teach effectively. To achieve this improvement, one must not only be alert to learn about, and always willing to try out, new instructional methods and devices, but must also be vigilant to prevent the loss, through disuse, of effective teaching techniques and skills once possessed.

The following discussion presents a number of suggestions concerning practices which are believed likely to contribute to the effectiveness of laboratory work; the term, "laboratory work," is here meant to include experiments demonstrated by the teacher as well as those performed by pupils individually, in pairs, or in groups. The fact that the suggestions are presented as theses, and are stated positively as if they were unquestionably true, is not intended to indicate or to suggest that they are other than expressions of opinion.

1. *The teacher of science should make entirely clear to the class before an experiment is begun, exactly what problem the experimentation is intended to solve.* In observing science classes in many schools, one is impressed by the frequency with which the teacher embarks upon a demonstration or permits the class to start their manipulations, without first stating definitely the purpose of the laboratory exercise. The teacher knows, of course, what the experiment is expected to show; it is obvious to her how that particular exercise is related to the work that has preceded or will follow it. She is likely, therefore, to take for granted that the class is equally well aware of "what the experiment is about." But in many cases part or all of the class are not. Frequently the pupils' bewilderment is patently obvious. As the experiment progresses, its purpose and relevance dawn upon the members of the class one by one. Usually most of them discover the reason for performing it before it has progressed far; but the confusion and uncertainty that exist before that point of understanding is reached is entirely needless and could be eliminated if the teacher would follow the practice of making clear at the start of every experiment, the question to which its

performance is expected to provide the answer. An effective way of achieving this is to write a statement of the problem of the experiment on the blackboard before any procedures for solving it are begun.

2. *The most effective way to introduce an experiment is to state its problem in the form of a question.* Thus, "Nitrogen," or "To study nitrogen," is less challenging than "What are the properties of nitrogen?" Also, "Ventilation," or To study ventilation," lacks the stimulus that is provided by "How is good ventilation provided?" "Propagation of light," or "To study how light travels," has a weaker appeal to the pupils than "How does light travel?" Questions introducing experiments, however, should usually be stated even more directly than are the three given as examples here. An even better type of problem statement is indicated in the next paragraph.

3. *The question which introduces a laboratory exercise should be so worded that the pupil will be able to answer it directly and with confidence after having observed the results of the manipulations.* In other words, the question (or questions, for often an experiment requires more than one) should indicate to the pupil the nature of the facts he is seeking and its answer should be clearly revealed by the procedures. This is especially important with more elementary courses, with the less mature pupils, and with those of lower ability. Thus, "What are the properties of nitrogen?" is more difficult and less challenging than "What are the color and the odor of nitrogen? Does it burn? Is it a supporter of combustion?" "How may good ventilation be provided?" fails to stimulate as strong a desire to perform the experiment and "find out," as does this question, "Is a better circulation of air through a room secured when the window is opened at the bottom, at the top, or at both the bottom and the top?" "How does light travel?" is less definite and dynamic than "Does light travel in straight or in curved lines?"

4. *The teacher, when demonstrating, should make certain that all the pupils can clearly observe what is taking place and should then hold all members of the group responsible for observing whatever phenomena the activity provides.* Many teachers of science in their conscientious efforts to insure that the pupils "know what happens" are prone to describe the observations before, during, or immediately after the experiment. It is much better to say, "Watch closely to see what happens when the compass is brought near the coil," than to say, "You will see that the north

pole of the compass turns toward the coil when the compass is brought near it." Often at the completion of a demonstration, not all, and occasionally none of the members of the class can state with certainty what were the results of the manipulations or procedures. The teacher is therefore tempted to tell what happened, both in order to make sure that all the pupils know what they were expected to observe and in order to save class time. In every such case, however, it is better practice first to reintroduce the problem in order to make certain that all the pupils know what they are to try to discover, and then to repeat the experiment, while making the class understand that they are expected to make the necessary observations for themselves.

5. *The teacher should encourage the pupils to record only what they actually observe.* Too often the emphasis (or at least the pupils so believe), is on "getting the right answer." It is all too common, for example, in classes of general science, biology, or chemistry to have the pupils report that the oxygen made with potassium chlorate and manganese dioxide is colorless and odorless when it obviously is neither. Not infrequently while observing laboratory work, one hears the pupils ask the teacher, "Shall we put down what it really did or what it ought to have done?" In a disconcertingly large number of such cases the teacher replies, "Write what should have happened." Such practices defeat important purposes of laboratory work and train the pupils in unscientific habits rather than in the correct use of scientific method.

6. *Every experiment, whether performed by the teacher or by the pupils, should be reported in some way.* Children in the grades and pupils of the junior high school, especially, are likely to be impatient when asked to record their observations. They are prone to say, or at least to think, "I don't want to write that up. I can remember it all right." But if the laboratory exercise is sufficiently valuable to deserve a place in the course, it is sufficiently important to be recorded in some manner that will promote its accurate subsequent recall. Oral reporting is excellent but it should be supplemented with a written record to which the pupil may refer later. The methods of recording may and should be varied. There is no justification for having the pupils report any considerable number of experiments in any way which demands a large amount of writing, because the teacher is certain not to have time to read the papers critically; and unless she does examine them with sufficient care to give every pupil

the constructive criticism his individual report demands, the writing in detail descends to the level of busywork and time-killing. The pupils who are required to include much written material in their reports soon come to realize that the teacher cannot possibly read all their papers or even a respectable sampling of them; consequently, knowing that she cannot adequately "check up on them" they fall into many undesirable and unscientific practices, such as copying somebody else's statements; copying the directions for performing the experiment, with or without change of mode or tense; making careless and sketchy answers to questions; or in other ways submitting scamped and substandard reports.

An occasional extensive written report is desirable, but, from the standpoint of practicability, it is so only provided that the teacher can find the time to give every paper an individual critical reading. The critical reading is mandatory because such a report is essentially an exercise in English composition of which the primary function is to give the pupils training in writing exposition.

Like too much detailed reporting, the recording of experiments wholly or chiefly by writing single words or short phrases in blanks is equally to be condemned, because this practice usually results in an incomplete understanding of the experiments and probably in other outcomes which are undesirable.

Fortunately most laboratory exercises can be reported in one or more ways which indicate satisfactorily the important observations and inferences while requiring only a small amount of time and effort on the part of the pupils and no expenditure of the teacher's out-of-class time (see Thesis 7, below). For example, many experiments can be reported by the "moving-picture method," that is, by having the pupils draw a series of simple diagrams to show what was done and what happened; by having them draw and label one or more diagrams; by having them complete and label a mimeographed diagram provided by the teacher; or by having them write responses to a few short-answer test items, designed to stress the important points in the experiment. These latter can be used effectively in as wide variety as is provided in a good modern achievement test; that is, they may consist of modified true-false, completion, modified multiple-response, best answer, or matching items.

7. *The pupils should record their observations at the time these are made or immediately upon the completion of the experiment;*

and, in most cases, they should make their reports of the experiment immediately upon its completion. Pupils are careless about recording their results; also, frequently, the progress of the experiment makes immediate recording difficult. Moreover, after the experiment has been completed, most of the class would rather "take up something else" than to do the work of reporting. Many pupils, especially those in physics and chemistry classes, dislike using class time for writing up their experiments. They prefer to "do" the experiments in class and to write them up at some later time—often much later. As a result, by the time they are ready to prepare their reports, they recall their observations inaccurately, incompletely, or not at all; hence, they are likely either to hand in materials that are below acceptable standards, or to copy reports secured from other pupils.

8. ***The teacher should try to examine the laboratory reports and to indicate errors while the records are being made and during the period in which the laboratory work is done.*** Conscientious teachers are likely to believe that they are obligated to take the laboratory reports home and to "go over" them in their out-of-class hours, so as to be able to return them in "corrected" form at a subsequent class hour. Except for the occasional extensive reports, which can only be read by the teacher out of class, little or no values are gained by the pupil from having the teacher read his report at home. On the contrary, he is most likely to benefit from suggestions and criticisms given him while he is recording his data or while he is making his report than from having his corrected paper returned to him a day or more later when the experiment is no longer clearly in his mind. The teacher would much better spend her evenings and week-ends in professional reading and in recreation than in trying with inevitable futility to "go over," or read critically, the numerous laboratory reports of the day or of the "marking period."

If the report demanded is in one of the brief forms already mentioned (Thesis 5), the teacher can check the correctness or indicate some, at least, of the shortcomings of an individual's report in a few seconds as she passes among the pupils at work; and though she will not be able to "cover" a class of forty or fifty pupils during each time they perform an experiment, she can nevertheless give every pupil some direct personal attention every other or every third time. She can thus more effectively maintain good standards of work because she is constantly among the pupils supervising their experimenting and/or their

recording. Furthermore, she can evaluate each pupil's work habits and his laboratory achievement more satisfactorily through such direct supervision than she can from reading later the report which he has written to hand in.

In every case, the supervised reporting of an experiment should be followed immediately by a class discussion of it in which incorrect impressions are corrected, common errors are pointed out, applications are described, related problems and materials are introduced, and further related experiments are planned.

9. *Since some of the practices advocated in the preceding paragraphs demand more class time than is required by conventional procedures, the teacher should not hesitate to reduce the number of experiments customarily assigned to a course.* If a primary objective of laboratory work is to develop skill in the use of the elements of scientific method, then this goal cannot be achieved unless the numbers of experiments conventionally prescribed are substantially reduced. Nobody yet knows, with even approximate accuracy, how many experiments any course of science should contain. Fewer experiments planned and carried through in such ways as to secure the unique and fundamental values which such exercises can be made to provide will prove far more fruitful than large numbers performed and reported with the superficiality and haste which too frequently result from the attempts to perform all the laboratory exercises that have come to be accepted as belonging in the course.

NEWLY DEVELOPED PAPER MATERIAL FOR SHIPPING TAGS

Paper is now being made to do the job of metal and cloth tags in labelling war materials going overseas. The National Bureau of Standards and cooperating manufacturers have developed a paper material for tags that has very high resistance to tearing and scuffing, dry or wet. It eliminates the further use during the war of cloth, metal, and abaca manila hemp fiber as materials in shipping tags.

Federal specifications for tagboard material, recently issued, substitute non-critical fibers for the manila hemp and secures wet strength, as well as resistance to scuffing, through the use of synthetic resin. The tearing resistance of this board is equal to that of manila hemp board when dry, and when wet it is greater.

Instead of metal eyelets, paper patches affixed with water-resistant adhesives are specified. They withstand submersion in water indefinitely without coming loose from the tags, it is claimed.

THE PLACE OF INDUSTRIAL CHEMISTRY IN THE TRAINING OF HIGH SCHOOL CHEMISTRY TEACHERS

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Introduction

The variety of new products produced by chemical industries has been astonishing. Furthermore, the improvement in the quality of products manufactured has been almost miraculous. The importance of industrial chemistry in the training of chemists destined for positions in chemical industries has long been recognized and, in response to the above mentioned comparatively recent accomplishments, industrial chemistry, probably, will be assigned an even more important role in the training of chemists preparing to assume positions with companies engaged in the manufacture of chemical products in the future.

Only within recent years has industrial chemistry received any degree of recognition in the training programs of high school chemistry teachers. The scope of industrial chemistry is so broad and the background furnished is so vital that far greater recognition should be given to industrial chemistry in planning the programs of studies to be pursued by future high school chemistry teachers.

Importance of Industrial Chemistry to Chemistry Teachers

What has industrial chemistry to contribute to the training of high school chemistry teachers and to the enrichment of high school chemistry courses?

First, the astonishing progress of chemical technology up to the present time and the promise of amazing future developments gives to the beginning student of chemistry a strong initial interest in the study of chemistry.

This initial interest may be attributed partly to the expectation of learning interesting and useful information concerning the manufacture and uses of industrial products. During the early stages of the elementary chemistry course, therefore, the alert teacher of chemistry will introduce the study of appropriate and interesting chemical processes. At this stage of the elementary chemistry course, a class visit to an appropriate

nearby chemical plant will be stimulating to the class. Slides, film strips, and silent or sound motion pictures judiciously used may supplement the class visit to a chemical plant, the teachers description, and the textbook description of the chemical process being studied.

Through the above procedure, the initial interest in the study of chemistry will not be partially nullified by overemphasis of chemical theory during the early stages of the elementary chemistry course. In addition, added impetus will be given to the initial interest in the study of chemistry.

Second, the study of chemical processes constitutes an excellent means of maintaining, throughout the elementary chemistry course, the initial interest aroused.

Through independent study, daily assignments, and projects, varied individual interests in industrial processes may readily be recognized and considered.

Effectual instruction in any subject is partially contingent upon the degree to which interest endures throughout the span of the course. The teacher of elementary chemistry is indeed fortunate to have, at his disposal, a voluminous body of highly interesting, usable, and practical information concerning chemical processes to be used periodically in ministering to class or individual interests. Through prudent use of the body of information available, the teacher of chemistry should have little difficulty in sustaining enthusiasm for the study of elementary chemistry.

Third, the industrial chemistry course provides the chemistry teacher with the necessary background to cope with the varied interests of individual class members in chemical processes.

Admittedly, fundamentals of chemical processes only may be considered in the elementary chemistry course. However, it is quite obvious that if the fundamental facts concerning chemical processes are to be taught effectively, the teacher of the elementary course must have a good general knowledge of the more important industrial processes at his command.

The general public has long been interested in the applications of chemistry affecting daily life. The interest of the general public has, in turn, been absorbed by public school students who are interested in securing some knowledge of industrial processes beyond that which is found in the typical elementary chemistry textbook. Furthermore, their interests may include industrial processes which may not be found in the usual elementary

chemistry textbook. It is quite probable that when individual interests of students in elementary chemistry classes are canvassed that the widely diversified interests so discovered will require a good knowledge of industrial chemistry to competently answer the many reasonable and pertinent questions arising and to intelligently direct the projects which the students wish to investigate.

This background may be secured without the necessity of pursuing a formal course of industrial chemistry but the study of industrial chemistry in an organized class and under competent leadership is, probably, the most economical and logical method of acquiring this background.

Fourth, the study of industrial processes provides, to the student of elementary chemistry, additional insight into the practical application of theoretical facts and principles. Throughout the lifetime of an individual, he is constantly being called upon to make practical application of the theoretical facts he has learned. Teaching the student of elementary chemistry how to make practical application of theoretical facts through the study of chemical processes will develop a valuable attitude in the student.

The training of the student of elementary chemistry in scientific observation and thinking, therefore, may be partially accomplished through the study of chemical processes.

CHROME-PLATED CYLINDER BARRELS

Chrome-plated cylinder barrels of new automobile engines give longer service life, and the art of plating worn cylinders is developing into a science. New plating techniques which make engine cylinders highly resistant to wear and corrosion were presented at the meeting of the Society of Automotive Engineers by B. A. Yates.

Treated surfaces are showing a wear life several times greater than that of metals generally used, he said, assuring longer periods and higher operating efficiency between overhauls. He indicated that salvage of worn cylinders presents unusual problems. The preparation of the surfaces requires specialized techniques in grinding, honing and finishing, but scientific methods are proving satisfactory.

Chromium-plated piston rings, particularly with the top ring plated, drastically cut engine wear, according to Tracy C. Jarret of the Koppers Company, Baltimore, who presented data to show that with such rings, even under abnormal dust conditions, cylinder wear is cut one-half at least. The data indicated that a 2,000-horsepower engine operated 590 hours developed cylinder wear of only 0.003 inches when a porous chromium-plated ring was run in a chromium-molybdenum cylinder. With a plain cast-iron ring, 307 hours of operation produced more than twice this amount of wear.

A CARD GAME DESIGNED AS AN AID IN TEACHING THE CHARACTERISTICS OF GILLED MUSHROOMS

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Most of us have played the game of "Authors" as children. Most of us by virtue of this game learned to associate American authors with their principal works long before we studied American literature in high school. With the memory of this efficient teaching device in mind it was obvious that the principle might work for teaching the characteristics of gilled mushrooms preparatory to field identification.

With such an objective in view the game of "Mushrooms" was invented paralleling rather closely the old game of Authors but with modifications which we think add interest and which takes cognizance of the vastly different nature of the subject matter.

Forty-nine genera of gilled mushrooms were selected as including those mushrooms commonly found in the central states. The name of each of these genera is written separately on a card with three to six descriptive characters, enough to distinguish the genus, listed beneath the genus name. The fewest possible number of terms were used to characterize the genus. "Claudopus" for example, is a three-term genus as follows:—(1) spores pink; (2) stipe eccentric; (3) plants growing on wood. Such a combination of characters would scarcely be applicable to any other genus.

Four terms are needed to identify Amanita properly including (1) spores white; (2) volva present; (3) annulus present; (4) gills free.

Lentinus is described with five characters: (1) spores white; (2) plants reviving; (3) gills toothed on the edge; (4) gills unequal; (5) gills acute at the edge. It was considered necessary to use six terms to characterize Lenzites, viz., (1) spores white; (2) pileus corky; (3) gills corky; (4) gills unequal; (5) pileus dimidiate; (6) pileus sessile. The genus deck included four three-character cards; twenty-three four-character cards; sixteen five-character cards; and six six-character cards.

Another set of cards, each one $2\frac{1}{2}$ inches by $3\frac{1}{2}$ (ordinary playing card size) was prepared, and on each of the smaller cards

one descriptive characteristic of a mushroom genus was printed.

The game may be played by two to ten players. The genus cards are distributed equally among the players. The "characteristic" cards are then shuffled and five are distributed to each player. The remaining number of characteristic cards are placed in a pile in the center of the table and may be drawn from later.

Each player observes his genus cards and notes the number and kinds of 'characteristics' that he needs. The player in his turn may demand a 'characteristic' card from any other player and if the request cannot be honored the player draws a card from the top of the deck in the center of the table. A player may continue to call for characteristics as long as he is lucky enough to obtain the card he wants either by calling or drawing. When a player has all of the characteristics that are needed to identify a genus he has a "book." A three-term book counts three points. The value of any book depends upon the number of characteristics listed on the genus card. At the conclusion of the game the player with the most points wins the game.

There are many possible variations. If there are eight or ten players it would be practical to use all of the genus cards. If there are fewer participants, it may be desirable to separate the genus deck into two decks based on white and colored spore characteristics. A teacher may select only those genera that he may want to emphasize to his class at any particular time.

I have experimented with this game on two classes of people. (1) Those not botanists and not acquainted with any mushroom genus or the terminology used in mushroom descriptions. Such information is not necessary in order to be able to play this game. One can win at Authors without knowing the details of biography, or being able to evaluate the literary merit of the productions. To those not familiar with mushrooms the game does create an interest in this group of plants. The interest would be enhanced if each genus card would have a colored and accurate picture of the mushroom described.

(2) I also used this game as an aid in instruction of a class taking a mushroom course last Summer. Before the cards were used the students were made acquainted with the macroscopic and microscopic structure of mushroom fungi and they became familiar with the terminology of the subject. The various mushroom genera had been discussed and the criteria by which such genera are separated. As is usual in this type of instruction these students gained a general picture of taxonomic distinctions but

were overwhelmed by the fifty genera whose characteristics they were expected to know. The cards were then used as previously described and the members of the class learned the characteristics of 40 to 50 genera in an amazingly short time. This was a distinct aid in the field work that followed. The students were able to approximate the genus to which a mushroom belonged without the aid of a key.

So far as the author is aware this idea is original and it has been so successful in teaching the taxonomy of this group of fungi that it is believed it could also be extended to taxonomic instruction in trees, flowering plants, birds and other organisms in nature.

A PROOF OF THE CENTRIFUGAL FORCE FORMULA

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In the teaching of elementary physics, there is no proof that causes more confusion than that of the centrifugal force formula. The proof as given here is somewhat similar to that appearing in Blackwood's *Introductory College Physics*, but it is my hope that the line of thought followed is more exact and leads to a clearer understanding of the problem.

To begin; in relation to the effect on an object moving in a circle, there is no such thing as centrifugal force. If it were true that an equal force oppositely directed balanced the centripetal force, there could be no acceleration toward the center of the circle of rotation. Considering the motion of the rotating mass at any point of its circular path, if no unbalanced forces acted upon it, it would continue moving in the same direction and thus would move out along the tangent drawn to the circle at that point. The unbalanced force acting toward the center of rotation overcomes the inertia of the moving mass and causes it to deviate from its straight line path.

Since the centripetal force is unbalanced and acts toward the center of the circle of rotation, from Newton's second law, the acceleration caused by it will be toward the center of the circle. The problem now is to derive an expression for this acceleration.

In Fig. 1, the actual path of the object is represented by the circle. The simultaneous action of the acceleration a toward the

center and the constant tangential velocity v causes the object to move along the arc from A to C in some period of time t. However, it should be clear from the diagram that in this time, the object has moved a distance $\frac{1}{2}at^2$ measured along the line AD and at the same time has moved through the distance vt measured perpendicular to this line. The proof of the formula depends upon a proposition from plane geometry. The proposition is that the perpendicular drawn from any point on a circle to the diameter is the mean proportional between the segments of the diameter.

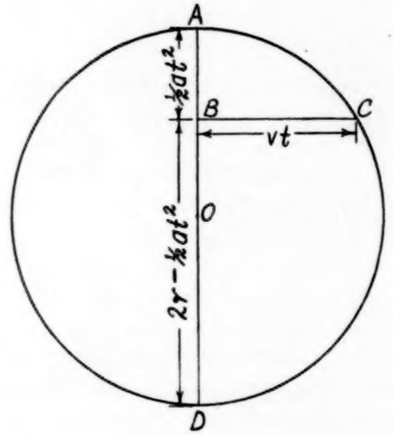

FIG. 1

From this proposition, referring to Fig. 1

$$\frac{AB}{BC}=\frac{BC}{BD} \tag{1}$$

or in terms of velocity, acceleration and time as indicated,

$$\frac{\frac{1}{2}at^2}{vt}=\frac{vt}{2r-\frac{1}{2}at^2}\,. \tag{2}$$

This reduces to the form

$$a=\frac{v^2}{r-\frac{1}{4}at^2}\,. \tag{3}$$

Now in Fig. I, it is to be noticed that our analysis holds true only as long as a is in the direction AB and v is perpendicular to

this direction. As soon as the object moves away from the point A along the arc of the circle, the pull toward the center, and thus the acceleration, is no longer in the direction AB. The direction of v changes also as soon as this occurs, since v is always along the tangent. Therefore, in order to make our analysis exact, we must consider *instantaneous* conditions. That is, in (3) t must be made very small. A better way to state the condition would be: as t approaches zero, equation (3) more nearly approaches the true value of the acceleration so that in the limit as t approaches zero,

$$a=\frac{v^2}{r} \tag{4}$$

which is now the exact value of a at any point on the circle. Using the correct units, we may write,

$$F=ma. \tag{5}$$

Substituting from (4) we have,

$$F=\frac{mv^2}{r}, \tag{6}$$

which is the so called centrifugal force formula.

In terms of a mass whirling on the end of a cord, the tension in the cord tends to separate the fibers of the cord. It is stated that action and reaction are equal and opposite. However, the action is upon the mass in motion and the reaction is upon the earth which can be considered to have infinite mass in relation to the small mass on the end of the cord. Action and reaction are both unbalanced forces, the action of the tension of the cord on the small mass is quite noticeable, the reaction of the tension of the cord on the earth is usually not considered. The acceleration imparted to the earth by this pull is unnoticeable.

GLIDER TORPEDO CARRIES OWN WEIGHT

A gyroscope-controlled glider torpedo is the subject of patent 2,339,011, granted to H. A. Gurney of Encino, Calif. Once launched, automatic controls take over and hold the winged missile on a true line against the enemy ship or other target.

A feature of the torpedo is its suspension beneath the carrying plane in such a manner that its wings provide the necessary lift during flight. This, the inventor claims, will enable light, fast planes to carry relatively heavy explosive missiles into action, and be free to function as fighters as soon as they have released them.

GEOGRAPHIC INSTRUCTION FOR A GLOBAL AGE

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The keynote of our time is geopolitical incompetency. In less than forty years, we have had two world wars and a great world wide depression. These three catastrophies occurred because mankind had not attained sufficient understandings to solve the new problems of a global age. The present war was caused directly by the faulty geopolitical thinking of our enemies. The inevitable defeat which they will suffer is part of the price they must pay for defective thinking. Inadequate geopolitical thinking on the part of our allies and ourselves was indirectly contributory to the outbreak of the war. We believed that the theft of Manchuria, the conquest of Abyssinia, the destruction of the legal government in Spain, the violation of treaties and the persecution of Jews by the German state were remote events that would not materially affect our lives. We failed either to adjust world conditions to avoid war or to prepare for conflict. We must pay for our negligence in "blood, sweat, and tears."

The educational crisis that today confronts the world is more critical than the war. The United Nations are surely approaching victory, but our ability to organize and to maintain an effective post-war world is uncertain. Other wars will probably follow this one and we will probably experience other great depressions, unless the peoples of the world acquire a more effective grasp of international problems. We are living in a global age and are mentally unprepared for its problems. Walter Lippmann describes our confusion vividly. On p. 3 of *The United States Foreign Policy: Shield of the Republic* he states,

> As the climax of the war finds the people of the United States approaching a national election, we must face the fact that for nearly fifty years the nation has not had a settled and generally accepted foreign policy. This is a *danger* to the Republic. For when a people is divided within itself about the conduct of its foreign relations, it is unable to agree on the determination of its true interest. It is unable to prepare adequately for war or to safeguard successfully its peace.

The mental unpreparedness, noted by Lippmann, is especially critical in a democracy, for national policy in a democracy is based upon public opinion and can be no more competent than the thinking of its citizens. In the long run, a democratic govern-

ment, like any other human institution, will survive only by functioning successfully. In an age of world wide commercial exchange, we can no longer live nor afford to think in isolation. We must make decisions on a global basis, because our daily lives are affected by world conditions. There is an alternative to a blind and fatalistic acceptance of continuing international crises; it is to use the power at our disposal to create and preserve everywhere conditions favorable to our interests. As a nation, we have no need or desire to acquire the territory of other peoples and this fact gives us a unique opportunity for constructive leadership in the creation of a better world. Our interests are to support peace, freedom, and world prosperity and are, therefore, not in conflict with the legitimate interests of any other people. But before we can assume world leadership, the peoples of the world must be certain that we agree among ourselves that the advantages of world leadership justify its responsibilities. The stability of our national policies must be unquestioned.

Stable national policies rest upon general agreement with respect to national interests and can be achieved only by widespread understandings of the issues involved. Before our citizens can make effective global judgments, they must think realistically in terms of specific regions, specific peoples, and their specific problems. Although we are living in "One World," it is not everywhere alike. India and Germany are dissimilar and we must include differences of regions, of peoples, and of problems in our thinking to reach effective decisions. Failure to consider the distinctive geographical personality involved in each problem means basing conclusions of policy on incomplete and often inaccurate data. This will, inevitably, result in mistaken judgments, bringing catastrophies to ourselves and to other peoples of the world. The only effective means to develop public thinking to a level comensurate with the needs of a global age is by an educational program supplying the requisite understandings of the world. The preservation of democratic institutions and the successful organization of a better world depend upon the attainment of this educational goal.

Geography must constitute the core of this educational program. It is the school subject most suited for supplying the world understandings required by the citizens of a democracy that is confronted by the problems of global age. It can roll back the mental horizons of students until they are able to think

in terms of the world and its component parts. Geography will occupy a large place in the elementary and junior high schools and will become a basic subject throughout the high schools. Geography has held this position in the schools of Britain, France, Belgium, and the Netherlands as a result of the needs of empires and has been of core importance in Germany and in other parts of Europe as a consequence of the needs of world trade. The world commitments of the United States will produce similar results here.

Procedures in the geography classroom and the subject matter treated must be revised to adequately prepare citizens for the needs of a global age. The major emphasis should be placed upon the aspects of the geography of each region which affect world affairs. The sweeping character of these changes can be seen by examining the situation with respect to India. Effective thinking about India in the modern world requires a series of complex understandings, namely:

(1) that the problems of India involve one-fifth of humanity and are of an urgency that cannot be ignored with safety;

(2) that India is a land of recurrent famine, as a result of an excessive population, an unsatisfactory economic structure, and the vagaries of a monsoon climate;

(3) that the appalling poverty and ignorance in India result, mainly, from too large a population in proportion to resources and, therefore, cannot be corrected by political action or political independence alone;

(4) that, although these conditions can be improved, somewhat, by a better use of the available resources, such improvement is made difficult by existing internal political, social, and economic conditions;

(5) that the people of India are dissatisfied with British rule in India, but have been unable to agree upon a workable substitute as a result of ignorance, poverty, and disunity in language, in religion, and in caste.

(6) that the various problems of India are parts of a geographic whole and cannot be understood apart from the distinctive environment and people of India.

These concepts must be developed concretely and the individual students must acquire realistic understandings of these conditions. Poverty can be made specific by a study of pictures of homes and villages. Its cause can be developed by discussion of the size of farms and this, in turn, related to population density. Various difficulties in improving agricultural and other living levels can be analyzed in detail. The many problems which must be solved to attain satisfactory government in a land of such great poverty and such extreme diversity of population may be considered individually. Similar procedures may be employed to develop other desired concepts. All this takes

time, but, if adequate concrete material is used at each step, the students will acquire a group of understandings that can form the basis for effective citizenship with respect to India. Less comprehensive work will not achieve the desired result and is, for the most part, a waste of time and effort.

In the past, unfortunately, much work in geography consisted of the memorization of concise generalizations which held little specific meaning for students. The geography teacher of today must reach beyond such narrow limits and deal fully with the contemporary problems of our age. Newspaper, magazines, and the radio should be tools in the daily classroom. The national government should not only assure full freedom of the press and radio to provide teachers with access to truthful and complete information, it also should see that full news reports of the highest quality were available for future citizens during school hours. The schools in a democracy have a greater function than the issuing of ration books. The teacher of geography must be a student of national and world affairs. Such books as Lippmann, *The United States Foreign Policy*, Bowman, *The New World*, Spykman, *America's Strategy in World Politics*, Willkie, *One World*, Grew, *Report From Tokio*, and De Seversky, *Victory Through Air Power* should supply the teacher with an abundance of material with which to challenge every class. What is required is concrete, specific experiences and these should be provided for every region.

If the time allotted in a curriculum is inadequate to permit meaningful experiences for all the areas to be taught, it will be desirable to concentrate the available time on part of the areas. In planning work, it is essential to emphasize those aspects of the regional personality which have world significance. In many courses of study and in many text books, this is not done. Yet, the desirability of such selection appears obvious. Clearly, the demand by the people of India for independence is one of the geographic realities and is of much greater world significance than the fact that cotton is grown in the northwestern part of the Deccan Plateau or the fact that jute is grown on the Ganges Delta. Clearly, the pressure of population in Japan and the militaristic outlook of Japanese leaders were pertinent realities that should have been included in the study of Japanese geography. Obviously, the disagreements over international boundaries in Europe and the economic stress created in Europe by excessively high tariffs are important enough to deserve

school study, since they can involve our nation in war.

The need for a different kind of geography teaching is not limited to the treatment of foreign regions. Within the nation, new problems confront us. During the depression, the activities of the federal government were enlarged enormously to provide emergency services, which the states and other lesser governmental units did not handle. During the war, another kind of crisis has continued the need for expanding federal control. After the war, the widespread depletion of our resources and the problems of reorganizing our economy for peace will probably result in further extension of the scope of the national government. The character of the internal policies of the national government has already become of major significance to everyone. Effective citizenship now requires greater understandings of affairs in various parts of the country than were formerly needed. The necessity for these understandings will probably become greater in the future.

Geography must contribute these understandings by dealing with the local conditions underlying regional problems. In studying the geography of the South, the emphasis should be laid upon the poverty of the people. In studying the geography of the corn and wheat belts, the problems of price variation must be considered. In studying the geography of the Pacific Northwest, the need for a constructive forest policy must be stressed. Region by region such understandings must be developed, for although it is one country, the problems which must be solved vary from section to section and must be treated individually.

We are living in a new age with increased educational demands. We are confronted with new problems that require comprehensive regional knowledge for effective solutions. The emphasis of our teaching must be shifted to reach and deal adequately with the critical national and international problems that confront citizens in a global age. The task is great, but a new type of geographic instruction can produce students of world and national affairs, equipped to use geographic understandings effectively in solving the problems of our time.

LETTERING MACHINE

Lettering and figures are put on blueprints and tracings by a typewriter-like machine, large enough to accommodate tracing cloth or paper of any size without folding. Operated by a typist, it saves the more costly time of a draftsman.

NOTES FROM A MATHEMATICS CLASSROOM

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67. More About Graphic Solutions. In section 57 (Oct., 1943) I expressed disapproval of the statement, often found in new curriculums that the course in algebra should devote more time to graphic solutions of problems. Since I have found some teachers who agree with me, I am encouraged to discuss the question further. Consider, for example, the solving of $3x+4y=1$ and $5x-2y=19$ by finding the coordinates of the intersection point of their graphs. No normal person would solve such a set by drawing the graphs any more than he would use a graph to find the cost of five pounds of sugar at six cents a pound. I grant that when the method is discussed in class the pupils think that the method is clever and unusual. But if the pupils are given such sets to solve for homework and told to use any method, few pupils will use graphs. We might try to justify the method by saying that it is a preparation for other problems in which graphic solutions are unavoidable, but why not wait until that problem is reached? Just as we should not belittle algebra in the minds of the pupils by forcing algebra to do what arithmetic can do, so we should not use graphs for problems that are better solved in other ways. The graphic solution of a single set is worth not more than ten minutes in the classroom, and then the teacher may well say, "I know none of you would be so foolish as to use this method unless you like to do simple things in a hard way."

The word *graphic* is often misused. If a problem is solved by a scale drawing we should not say that the solution is graphic. Problems of interception and radius of action (see *Elements of Aeronautics* by Pope-Otis) and many trigonometric problems are solved by scale drawings. But in a high school class, or any other class, I would not call these graphic solutions. To the pupils a graph implies the use of cartesian coordinates or the presentation of statistical data by broken lines, circle, pictures, and so forth. Let's call a scale drawing a scale drawing.

In section 57, to which I referred, I mentioned that a graphic solution of a time-rate-distance problem should not be used unless the graph can contribute something that cannot be found from an arithmetic or an algebraic solution. The question then is: Can the graph contribute anything?

Consider the problem: A plane leaves airport A at 200 mph (the modern way of writing ***miles per hour***) toward airport B. Three hours later a plane flying 150 mph leaves B, which is 1000 mi. from A, and flies toward A. How soon do the planes pass?

By arithmetic, the planes approach each other 350 mph, and the planes are 400 mi. apart when the second starts. Hence the planes pass in $400 \div 350$ hr. after the second starts.

If we draw a graph for this problem using d and t axes, we have a line starting from the origin with a slope of 200, and a second line with a slope of -150 starting from $t=3$, $d=1000$. The graphs show that the time of passing is 4.1 approximately, and that d is 830 approximately. The graphs will contribute something additional if we next proceed as follows:

Draw *any* line (and the teacher should have different pupils draw different lines) parallel to the d axis. The line intersects the graphs in two points. The vertical distance between these two points shows the distance between the planes at that particular *any* time. The ordinates show how far each plane has moved during that time. And since we have drawn *any* line (with much emphasis on *any*) the graphs give a picture of the situation at *any* time.

Briefly, the arithmetic solves a single problem while the graph solves more than one problem. Unless this distinction is emphasized and appreciated, the graph has no value.

Here I wish to warn the inexperienced teacher against trying to do too much with this graph. The equation of one graph is easily seen to be $d=200t$. But this is a dangerous time to call attention to that fact since a pupil may then ask how the equation of the other graph is found. Much time can be wasted by raising questions that cannot be satisfactorily discussed at that time.

Mixture problems (such as: how many gallons of 20% cream and how many of 30% cream should be mixed to form some gallons of 22% cream) are good material for graphic solutions. But again, the graphic methods (such as those explained in farmer's handbooks) that solve a single problem should not be considered. The graphs must solve an entire class of problems. Some work of this kind is found in the ***Second Course in Algebra*** by Lennes, p. 210. See also the article by Ralph Calvert in the *Mathematics Teacher*, May, 1943.

68. Tricks for Solving Verbal Problems. One of the topics

in which I have been greatly interested for many years is that of how best to teach the verbal problems of algebra. At times I have offered suggestions that were speculative rather than practical. Hence it is a great satisfaction to find that some suggestion is winning favor. In an article written in the *1932 Yearbook of the National Council* I presented a method based on guessing or estimating the answer, and this idea has now found its way into the new *Algebra* by Schorling-Clark-Smith.

At that time I wrote "the method consists in (1) guessing the answer, (2) indicating the arithmetic work necessary to check the answer, and (3) substituting x for the guess. But the arithmetic work must not be performed; it must only be indicated." Thus, if a pupil multiplies 5 by 3 he should write 5×3 not 15. Thereby the pupil becomes conscious of the relations between the variables and the given numbers in a problem.

I experimented with that scheme for more than a decade and then found that I could do better by the simple expedient of introducing sets of equations earlier and of having the pupil use two equations instead of one equation. In a coin problem, for example, the pupil is inclined to add the number of nickels and the number of dimes and set the sum equal to the value of the coins. By having the pupil guess an answer and then test his guess, he can be taught that he must first multiply the number of nickels by five. However, when he uses n for the number of nickels and d for the number of dimes, he writes

$$5n+10d=\text{the value of the coins.}$$

Likewise, in other problems, I have noticed that many of the usual errors just do not happen. And, unless a problem involves a single unknown, it can best be treated after sets of equations have been studied. Thus difficulties are removed by merely changing the order of the topics—a simple remedy.

A comparison of the algebras of today with those of twenty years ago shows that sets of equations are being introduced earlier and earlier into the course. This can be done as soon as the pupil has learned to solve linear equations with fractional coefficients. The early introduction of sets is one of the outstanding improvements of the last twenty years.

69. Notes from Other Classrooms. At a recent meeting of the Men's Mathematics Club of Chicago and the Metropolitan Area (the title may be clumsy but it indicates the membership) the program was an "experience" meeting, that is, various

members spoke of some of their favorite pedagogical devices. A scheme mentioned by W. W. Barczewski of Waukegan was new even to the old teachers. A pupil is called to the board to recite a proof of a theorem or exercise in geometry, but the pupil is not allowed to talk. He must make his meaning clear merely by drawing or pointing to lines in the figure, by lettering or marking it in any way, and so forth. This calls for some ingenuity on the part of the pupil and close attention by the class. It should be good entertainment on days when pupils are looking for "something different" or need some relaxation after a strenuous week.

Several members spoke of the plan of having frequently a short written test, lasting only five or six minutes, at the beginning of a recitation. Often a single well chosen exercise serves as a good test of the previous day's work or of the pupil's preparation for that day. Tardiness to class is discouraged if the teacher has time to write the problem on the board in the interval between classes so that the pupil can begin as soon as he enters.

The most remarkable thing about pedagogy is that teachers can use a variety of devices, teach in many different ways, and still in the end, turn out a rather uniform product. Two pupils, of the same ability, can learn their algebra in totally different ways from teachers using entirely different methods, and in the end both pupils have absorbed about the same amount of learning. Few things are more helpful than listening to other teachers talk about how they teach. Our teachers' conventions could be more profitable if teachers could be encouraged to talk more about their methods. The slogan "share your car" could well be changed to "share your experiences."

70. The Converse of the Pythagorean Theorem. Few texts mention the theorem: If the sum of the squares of two sides of a triangle equals the square of the third side, the angle opposite the greatest side is a right angle.

The converse may not be used as often as the theorem itself, but it is used, and it is used oftener than we think. Every geometry mentions the Egyptian rope stretchers with the knots for laying out a right angle. They were certainly using the converse, not the theorem. We expect pupils to learn and use the fact that the numbers 3, 4, and 5 can be used to form a right triangle; and that idea implies the converse. I suggest that the converse be made a part of the fundamental work in geometry.

AIR NAVIGATION AND THE SECONDARY SCHOOLS

HARRY C. CARVER
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Just what Air Navigation is, and what it is not, is at present largely a matter of point of view. Obviously the predominant point of view right now must and should be that held by our Armed Forces, and that means that the emphasis for the time being must for practical reasons be placed upon the *how*, rather than the *why*, of Air Navigation.

Most of you will be surprised to learn that prior to the outbreak of the present conflict our Army Air Force, now so heavily and effectively engaged in long range bombing, had taken almost no measures to provide an adequate supply of navigators upon whom the success of bombing missions so largely depends. But after the outbreak of hostilities, arrangements were made for the Pan-American Airways to instruct a number of the members of our Air Force in the art of air navigation. Two of those receiving this instruction, Captains Egan and Harbolt (now Colonels) adapted the material of this initial course to our war needs, wrote navigation manuals on the subject, and organized the first Army school of air navigation. Within two years from the birth of this School, trained air navigators were being turned out at a rate of approximately one hundred per month, and now the number may be estimated roughly as one thousand per month.

In order to appreciate the enormousness of this task, just suppose that you were obliged to develop and teach an entirely new course, and simultaneously build up an organization capable of turning out within two years graduates at a rate exceeding ten thousand per year. To make matters just a little more difficult, then assume that the development of an efficient teaching personnel was retarded by the fact that you were obliged at the outset to ship most of your best graduating students right off to combat areas because of the urgency of the situation. Again, it must be apparent that only very few of the instructors at that time had any previous experience at teaching: although experienced public school teachers fit readily into the staffs of the Pre-Flight schools, the instructors in the advanced navigation schools must fly with their students and therefore these

instructors must be selected from those who have gained navigation experience in the air.

But before attempting to discuss the content of a course in air navigation or to comment on matters of instruction, something must be said about the background of the average cadet: it is quite obvious that a curriculum must be tailored to fit the student to some degree at least. Initially, an attempt was made to secure boys with two years of engineering training as navigation cadets. However, the demands of our war industries and other branches of the Service were so great for engineering experience that it was quite impossible to secure a sufficient number of navigation cadets with this background to meet the needs of our rapidly expanding bomber force. To make a long story short, fifty percent of our navigation cadets right now have not graduated from high school, and many of those who are now capably navigating our heaviest aircraft through the night skies all over the earth have never attended school beyond the eighth grade.

But this statement does not mean that the mathematics and physics as taught by our secondary schools would not form a desirable background for instruction in air navigation. What it does mean is that in the past we have failed to teach these subjects to a sufficiently large number of our students, and that now when confronted with a national emergency the Army is obliged to do in an intensive and abridged manner the job that we should have done. The fact is, this war caught us *all* completely off guard. Why, if the Air Forces had requested ten million dollars seven years ago to equip and organize a school for training of navigators, they would not have received the appropriation; and if such a request and others of a similar nature had been referred to the voters, both you and I would have voted against the measure. There is no need for a scapegoat; just let us all admit our lack of foresight in the past and resolve to do a little better in the future. And it may be well to recall that if a reasonable degree of international security does not exist after the present conflict, and if we fail to recognize the fact that henceforth our air force is our first line of defense and fail to provide for it as such, our next war may explode over all the vital sections of this country in Pearl Harbor fashion and the war be over before we have time to turn our schools and colleges over for War Training and make and correct several million blunders. The next war will be lost quickly by the side

that is unable to withdraw rapidly a sufficiently large number of technically trained men from civilian life, and this means for us just one thing: the secondary schools in the future must devise some method of teaching more science to more of our students, or we must face the alternative of having all our schools and colleges regimented and absorbed by a new Federal agency. This we do not want.

But let us return to our topic of air navigation, which is but one aspect of the more general problem.

Since this war required the immediate training of thousands of navigators and our pre-war educational system did not produce a sufficiently large number of young men capable of grasping within a short interval the *why* of navigation, the Army Navigation Schools have been obliged to concentrate on teaching the *how* of navigation. This means that they have been forced to evade mathematics and to teach their cadets to solve problems by mechanical, graphical and tabular methods rather than by analytical means. It must be admitted that in many cases these non-analytical methods are best suited for practical air navigation, but there are numerous instances in which a direct analytical approach yields both simpler and more accurate solutions. Frankly, I have never heard the words sine or cosine used by an instructor in navigation while performing his regular duty in either the classroom or in the air. I doubt if 20% of the instructors in dead reckoning in the Army Navigation Schools have ever studied plane trigonometry, and probably less than 5% of those teaching celestial navigation have studied spherical trigonometry. This just about answers the question "What Air Navigation Is Not," at least so far as our Air Force is at present concerned. In spite of all the navigation exercises that are to be found in the numerous and recent texts on plane and spherical trigonometry, our Army Navigation Schools cannot teach air navigation for this war in the manner suggested by these texts. One year's study of algebra and geometry simply does not penetrate deeply enough into the minds of our fourteen year old children to serve a useful purpose, say, six years later. All students should be obliged to study some type of mathematics during each year of high school: the present courses will be found adequate to meet the needs of some students, but for others we must devise new courses in which the theory and logic of mathematics is practically ignored and useful applications are stressed.

Some critics have facetiously remarked that the Army Schools

have been forced to evade mathematics because their teaching staffs are not capable of doing this work. This distorts the picture: the fact is that this condition could and would be remedied quickly if such procedure were desirable. In each class of graduating cadets we now have a number of men with master and doctor degrees in mathematics and science—some have held important positions in our Universities and other educational systems. If these men demonstrate a marked proficiency in air navigation, they are now almost certain to be assigned to teaching rather than to combat duties. But so long as the average cadet cannot readily grasp the analytical approach to navigation due to his high school elections, an excellent navigator with but a high school diploma under proper supervision may develop into a better navigation instructor than a Ph.D. in mathematics whose interest and ability in air navigation is definitely limited.

I admit that two years ago several of my friends and colleagues inspected a number of Army Pre-Flight and Advanced Schools and that their reports were honest, true, and showed that the instruction in those schools at that time was far inferior to that of our secondary schools. How could it then been otherwise? But it is only fair to report now that so far as some of these schools are concerned, the boot is now on the other foot: some of these Army Schools are now doing a better job than we are in the teaching of our larger courses that admit of a comparison. Naturally, the Army has nothing to compare with our small graduate and specialized courses. Let us see how this change has come about.

First and foremost, the Army has selected extremely capable officers to head these schools: their innate abilities compare very favorably with those of the average college president, and they are extremely eager for constructive criticism. Ordinarily over 5% of graduating navigators are selected on the basis of ability and personality to become instructors. They are first sent to an instructors' school for further study and instruction in the art of teaching, and then are assigned to the various navigation schools. Those demonstrating outstanding ability as teachers are retained by these schools; the others simply move along to combat areas as navigators and rejoin their previous classmates. After teaching for awhile, most of the instructors prefer to be shifted to a combat zone—I know that you will sympathize with them.

Each lecture in the eighteen week course has been written by

an instructor who is believed to be particularly qualified for his special assignment, and his work when completed is minutely criticized by other instructors. Revisions of these written lectures are frequent. Each instructor is required to read and study each lecture before delivering it to a class, the students are given a printed outline of each lecture with spacing provided for the taking of notes, and then receive a mimeographed set of exercises relating to the subject matter of the lecture. Literally thousands of problems with their solutions have been worked out by these instructors and grouped into sets identified with numbers corresponding to the number of the lecture. Many of these sets of exercises may be graded by electrically operated business machines, so these schools have solved their problem of providing practice exercises and examinations in a manner that warrants our envy. I have seen more than twenty different sets of exercises pertaining to a single lecture, and a like number of sets of examinations from which an instructor might make a random and satisfactory selection for any point in the course.

I have only one criticism to offer on this set-up: since the answers were obtained by averaging a number of graphical solutions they are necessarily approximations. In most cases exact answers, better suited for grading purposes, could have been obtained more easily by mathematical means.

Although for the duration of the war our schools should make every effort to provide instruction in air navigation to aid their students who may end up in this branch of the Service, and should subordinate the *why* of navigation to the *how* whenever necessary at this time, I do not believe that the Secondary Schools should continue to teach these courses after the war along the lines that seem justified at this time. The present method of teaching employed by the Army reminds one of an attempt to teach surveying without presupposing a knowledge of geometry or trigonometry, and relying too much on field experience. Of course, we know that many capable surveyors have never attended college, and that automobiles and airplanes have been designed by men whose knowledge was more practical than theoretical. But these men made their contributions as pioneers, and left the matter of technical improvements to others with more highly specialized backgrounds. It takes more than the energy and mechanical ability of a Ford or Wright to build and increase the performance of the present day automobile and airplane. By the same token, the navigators of our

transport planes, ten or twenty years hence, will require a technical education far in excess of that possessed by our present day navigators, and our schools must be prepared to play an important part in the development of this new profession. The navigator of the future will have obtained a thorough training in mathematics, astronomy, physics and meteorology. And since the safety of a million dollar plane and the lives of many passengers will rest to a considerable degree in his hands, he must be one capable of shouldering a great responsibility. His duties will carry him to all parts of the globe, and this will so appeal to the youth of tomorrow that the competition for positions as air navigators will be keen, and this in turn will permit an increase in the requirements.

In a general sense, we all know what air navigation is: it is the air of conducting aircraft from a point of departure to a specified destination and of being able to determine the position of the craft within reasonable limits at any instant during the trip. But in a more restricted sense air navigation at present is not mathematical,—it is largely a matter of common sense, and the ability to work out graphical solutions and use specialized mechanical equipment efficiently. The Army has done a beautiful job in training the type of navigator that we need right now in vast numbers. But the training of navigators even in these Army schools will soon start to drift towards the mathematical end of the navigation spectrum: the rate of drift will depend largely upon the success that our schools may have in teaching more mathematics and science to the next generation.

Our schools and colleges must take immediate steps to do their part in laying the foundation for future technical developments in the field of air navigation, and this will require some highly specialized courses. It will be found that the applications of mathematics and physics to the problems of air navigation are both interesting and extensive, and that our students have a natural desire to explore this subject. As evidence of the growing interest in air navigation in all kinds of schools at the present time, I may remark that in a class of air navigation that I gave last summer at the University of Michigan, and which was designed especially for teachers who desired to introduce similar courses into their own institutions, three of the twenty-five individuals electing this course were nuns, and two were priests.

Individuals interested in research will find an extremely profitable and fertile field for their special abilities in air naviga-

tion—much remains to be done. Contrary to an article that appeared some time ago in a popular magazine and which was obviously written by one suffering from a sort of frustration, our Air Forces are most anxious to investigate all new theoretical and mechanical developments that seem to offer an opportunity to improve our navigation technique. I have seen and read a number of these carefully written reports; they were fair and unbiased. Fortunately some of the contributions were neither so fantastic nor as impracticable as the one to which I just made reference, and were eagerly adopted.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in Indian ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1844. *A. J. Zanolar, Collegeville, Ind.*

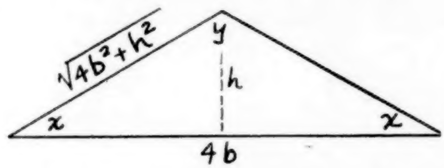
1846, 7, 8. *Hugo Brandt, Chicago.*

1848. *Edith McLoughlin, Romulus, N. Y.*

1849. *Proposed by Hugo Brandt, Chicago, Ill.*

In an isosceles triangle the sum of the tangents of the three angles equals $(-\frac{1}{3})$; if its area is expressed by the same number of square units as the number of linear units in its perimeter, what is that number?

Solution by William A. Richards, Berwyn, Ill.



Let the angles of the triangle be represented by the letters x, x, and y; let the base be $4b$, the altitude h, the area S, and the perimeter p. Then

$$S=2bh, \quad \text{and} \quad p=4b+2\sqrt{4b^2+h^2}.$$

Now, we know that

$$2\tan x+\tan y=-\tfrac{1}{3} \tag{1}$$

and

$$S=p, \quad \text{or} \quad 2bh=4b+2\sqrt{4b^2+h^2}, \quad \text{or} \quad bh=2b+\sqrt{4b^2+h^2}. \tag{2}$$

But

$$\tan y=\tan(180°-2x)=-\tan 2x=\frac{-2\tan x}{1-\tan^2 x}.$$

Then

$$2\tan x-\frac{2\tan x}{1-\tan^2 x}=-\tfrac{1}{3}, \quad \text{or} \quad 6\tan^3 x+\tan^2 x-1=0.$$

Factoring,

$$6\tan^3 x+\tan^2 x-1=(2\tan x-1)(3\tan^2 x+2\tan x+1)=0. \tag{3}$$

And, solving (3),

$$\tan x=\tfrac{1}{2}.$$

But

$$\tan x=\frac{h}{2b}, \quad \text{and hence} \quad b=h.$$

Now, from (2),

$$h^2=2h+\sqrt{5h^2}, \quad \text{or} \quad h=2+\sqrt{5}.$$

Hence, the required number is

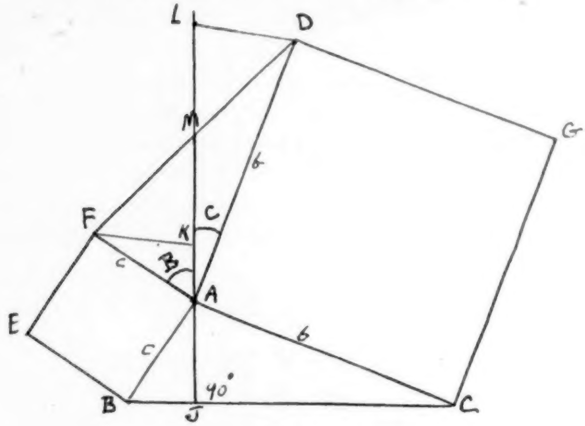
$$2bh=2h^2=2(2+\sqrt{5})^2=18+8\sqrt{5}.$$

Solutions were also offered by M. Kirk, West Chester, Pa.; Ralph O. Carruth, Clayton, Mo.; M. H. Pearson, Montgomery, Ala.; Alan Wayne, Flushing, N. Y.; Aaron Buchman, Buffalo, N. Y.; A. E. Gault, Peoria, Ill.; Helen M. Scott, Baltimore, Md.; Harvey Rubinstein, Brooklyn, N. Y.; Joseph M. Synnerdahl, Chicago and the proposer.

1850. *Proposed by Harvey Rubenstein, Brooklyn, N. Y.*

On the sides AB and AC of a triangle ABC, construct on the outside of the triangle squares $ABEF$ and $ACGD$ respectively. Draw DF. If AJ is perpendicular to BC at J, then AJ bisects DF.

Solution by M. Kirk, West Chester, Pa.



$$DM=\frac{b \sin C}{\sin M}=\frac{c \sin B}{\sin M}$$

$$MF=\frac{c \sin B}{\sin (180-M)}=\frac{c \sin B}{\sin M}$$

$$\therefore \quad DM=MF.$$

Another solution by M. H. Pearson, Montgomery, Ala.

Draw FK and $DL \perp AJ$ produced.

Then $\triangle$ AKF and ABJ are congruent, also $\triangle$ ACJ and ALD are congruent.

Hence $FK=AJ=LD$. From this it follows that $\triangle$ FMK and LDM are congruent, and hence $FM=DM$.

Solutions were also offered by Alan Wayne, Flushing, N. Y.; William A. Richards, Berwyn, Ill.; A. E. Gault, Peoria, Ill.; Hugo Brandt, Chicago; Aaron Buchman, Brooklyn, N. Y.; Helen M. Scott, Baltimore, Md.

1851. *Proposed by Norman Anning, University of Michigan*

It is given that

$a=1.58489$,	$\log a=0.2$
$b=2.51189$,	$\log b=0.4$
$c=3.98107$,	$\log c=0.6$
$d=6.30957$,	$\log d=0.8$

Use this table and gumption to show that

$$\frac{a^2+b^2-c^2}{2ab}=\frac{d+10a-10c}{20}=-0.88261.$$

From the data, $a=\sqrt[5]{10}$, $b=a^2$, $c=a^3$, $d=a^4$.

Hence

$$\frac{a^2+b^2-c^2}{2ab}=\frac{a^2+a^4-a^6}{2a^3}=\frac{a^4+a^6-a^8}{2a^5}=\frac{d+10a-10c}{20}$$

$$=\frac{6.30957+15.8499-39.8107}{-20}=-0.882561$$

(without any gumption!)

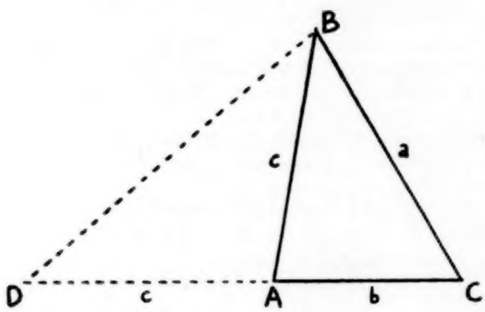
Solutions were also offered by M. Freed, Wilmington, Calif.; W. A. Richards, Berwyn, Ill.; Alan Wayne, Flushing, N. Y.; Gerald Freilich, Brooklyn, N. Y.; M. Kirk, West Chester, Pa.; Harvey Rubinstein, Brooklyn, N. Y.; M. H. Pearson, Montgomery, Ala.; Marcellus M. Dreiling, Collegeville, Ind.

1852. *Proposed by a Reader*

In a triangle if $a^2=b(b+c)$ prove that $A=2B$, a, b, c, being sides, with A, B, C, the angles opposite respectively.

Solution by Aaron Buchman, Buffalo, N. Y.

Extend side CA through A to D so that $AD=AB$. Draw DB.



Since $a^2=b(b+c)$, then $CD:BC=BC:CA$, and $\triangle BCD\sim\triangle BCA$. Thus $\angle D=\angle ABC$. But $\angle BAC=2\angle D$.

Therefore $\angle BAC=2\angle ABC$.

Another solution by W. A. Richards, Berwyn, Ill.

From the Law of Cosines

$$\cos A=\frac{b^2+c^2-a^2}{2bc}, \quad \text{and} \quad \cos B=\frac{a^2+c^2-b^2}{2ac}\cdot$$

But, it is given that

$$a^2=b^2+bc, \quad \text{and} \quad b+c=\frac{a^2}{b}\cdot$$

Hence

$$\cos A=\frac{b^2+c^2-b^2-bc}{2bc}=\frac{c-b}{2b},$$

and

$$\cos B=\frac{b+c}{2a}=\frac{a}{2b}\cdot$$

Now

$$\cos 2B=2\cos^2 B-1.$$

Then

$$\cos 2B=\frac{a^2}{2b^2}-1=\frac{b^2+bc-2b^2}{2b^2}=\frac{c-b}{2b},$$

which gives

$$\cos A=\cos 2B.$$

Now, angles A and B are each less than 90, hence

$$A=2B.$$

Solutions were also offered by A. E. Gault, Peoria, Ill.; M. Freed, Wilmington, Calif.; M. Kirk, West Chester, Pa.; Alan Wayne, Flushing, N. Y.; Hugo Brandt, Chicago; Helen M. Scott, Baltimore, Md.; Harvey Rubinstein, Brooklyn, N. Y.; Marcellus M. Dreiling, Collegeville, Ind.; M. H. Pearson, Montgomery, Ala.

1853. *Proposed by Leslie Smith, Hale, Mo.*

The sides of a triangle are 27, 28, 35. Prove that one angle is exactly three times another.

Solution by Aaron Buchman, Buffalo, N. Y.

It is at once evident that the problem as written is incorrect. It is easily shown that a triangle with sides 27, 48, 35 will give the desired relation. However, the generalized converse of the given problem, that is, to find triangles with integral sides in which one angle is three times another, seems of greater interest because of its broader scope. This derivation will be given. The steps may be put in reverse order, starting with equations (1) and (2) to solve the given problem.

In $\triangle ABC$, let $\angle B=3\angle A$. Draw BD in $\triangle ABC$ so that $\angle DBA=\angle A$. Let $CB=a$, $AC=b$, $BA=c$, $BD=x$, and $\angle BDA=n$. Then it is easily shown that $BD=DA=x$ and $CB=CD=a$.

In $\triangle CBD$ by the law of cosines, $a^2=a^2+x^2-2ax\cos(180°-n)$, or after simplifying,

$$2\cos n=-\frac{x}{a}. \tag{1}$$

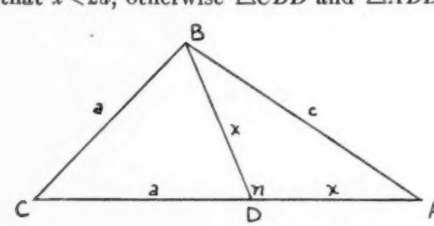
In $\triangle BDA$ by the law of cosines,

$$c^2=x^2+x^2-2x^2\cos n. \tag{2}$$

Replacing (1) in (2) and simplifying,

$$c^2=x^2\left(\frac{2a+x}{a}\right). \tag{3}$$

Relation (3) shows that c will be rational if $(2a+x/a)$ is a perfect square. If the denominator, a, is taken as any perfect square, then x must take some value such that $(2a+x)$, the numerator, is also a perfect square, with the limitation that $x<2a$, otherwise $\triangle CBD$ and $\triangle ABD$ are impossible.



Thus $a=4$, $x=1$, gives the basic rational triangle with sides $a=4$, $b=5$, $c=3/2$ or the basic integral triangle with sides $a=8$, $b=10$, $c=3$. No other value of x is possible for $a=4$.

Also, $a=9$, $x=7$, gives the basic rational triangle with sides $a=9$, $b=16$, $c=35/3$ or the basic integral triangle with sides $a=27$, $b=48$, $c=35$. No other value of x is possible for $a=9$.

In the same way, $a=16$ and $x=17$, $a=25$ and $x=14$, $a=25$ and $x=31$, etc., will generate further sets of basic integral triangles in which one angle is three times another.

Solutions similar to the one above were submitted by PFC Roy E. Wild, Durham, N. H.; Alan Wayne, Flushing, N. Y.

1854. *Proposed by James Holbrook, Shuqualak, Miss.*

A stone starting from rest slides down a roof sloping 30° to the horizontal, through a distance of 12 ft. If the lower edge of the roof is 50 feet high when, where and with what velocity does the stone strike the ground?

Solution by Julius Sumner Miller, New Orleans, La.

Assuming no friction, the acceleration on the roof is

$$a=g \sin 30°=16'/\text{sec}^2$$

$$V_0=0; \quad V_f^2=V_0^2+2as$$

$$=2\times 16\times 12.$$

Whence the final velocity at the edge of the roof is 19.6′/sec.

As it leaves the roof, the horizontal velocity is

$$V_H=V_0 \cos 30°=19.6\times .866=17'/\text{sec}.$$

The vertical velocity is, similarly,

$$V_V=V_0 \sin 30°=19.6\times .5=9.8'/\text{sec}.$$

Using $s=V_0t\pm\frac{1}{2}gt^2$, where

$$s=50'$$

$$V_0=9.8'/\text{sec}$$

t is found to be 1.49 sec.

This is the time of fall from the eaves. To slide the 12′ along the roof, we have

$$t=\sqrt{\frac{2s}{a}}$$

where $s=12'$ and $a=16'/\text{sec.}^2$, whence $t=1.23$ sec. The total time is, therefore, 2.72 seconds.

The horizontal distance is given by $V_H\cdot t=17\times 1.49$, whence the stone lands 25.3′ from the base of the building.

The final vertical velocity is given by $V_f^2=V_0^2+2gh$, where $V_0=9.8'/\text{sec.}$, and $h=50'$; whence $V_f=57.4'/\text{sec}$. The horizontal velocity $V_H=17'/\text{sec.}$, remains unaltered (assuming no resistance). Hence, by Pythagoras,

$$V_R=\sqrt{V_V^2+V_H^2}=59.8'/\text{sec}.$$

It hits the ground 2.72 sec. after starting; 25.3′ from the building; with a resultant velocity of 59.8′/sec.

Solutions were also offered by Joseph M. Synnerdahl, Chicago; Hugo Brandt, Chicago; Helen M. Scott, Baltimore, Md.; M. H. Pearson, Montgomery, Ala.; Aaron Buchman, Buffalo, N. Y.

PROBLEMS FOR SOLUTION

1867. *Proposed by M. Kirk, West Chester, Pa.*

Show that in a triangle the longest median is not drawn to the longest side.

1868. *Proposed by M. Kirk, West Chester, Pa.*

Show that $8 \cos^3 36° - 4 \cos 36° = 1$.

1869. *Proposed by Hugo Brandt, Chicago*

Find integers for a, c, m, n satisfying equations

$$a^2+7c^2=m^2$$
$$a^2-7c^2=n^2.$$

1870. *Proposed by Flora Mooney, Tecumseh, Mich.*

If the sums of the opposite sides of a quadrilateral are equal in pairs, the quadrilateral may be circumscribed about a circle.

1871. *Proposed by Alan Wayne, Flushing, N. Y.*

In rectangle $ABCD$ if $AB/AD = AD/(AB+AD)$, show that $\angle CAD = \arctan(\sin 18°)$.

1872. *Proposed by Adrian Struyk, Paterson, N. J.*

Two fixed circles tangent to each other at P are cut by a fixed secant which passes through P. A third circle, tangent to the secant at P, and cutting the other circles at A and B, is variable in size. Prove that $AB/PA \cdot PB$ is constant.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

Sorry—no names.—Editor

BOOKS AND PAMPHLETS RECEIVED

Principles of Air Navigation, by Bert A. Shields, *Lt. Comdr.' U.S.N.R., Formerly Chief Instructor in Charge of Civilian Pilot Training' Polytechnic Institute of Brooklyn.* Cloth. Pages vii+451. 13×20 cm. 1943. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $2.20.

A Primer of Electronics, by Don P. Caverly, *Commercial Engineer, Sylvania Electric Products, Inc.* Cloth. Pages xi+235. 13×20 cm. 1943. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $2.00.

Plane and Spherical Trigonometry, by Donald H. Ballou, Ph.D., *Assistant Professor of Mathematics, Middlebury College,* and Frederick, H. Steen, Ph.D., *Associate Professor of Mathematics, Allegheny College.* Cloth. Pages vi+179+10. 14.5×22.5 cm. 1943. Ginn and Company, Statler Building, Boston, Mass. Price $2.20.

Spherical Trigonometry with Tables, by Donald H. Ballou, Ph.D.

Assistant Professor of Mathematics, Middlebury College, and Frederick H. Steen, Ph.D., *Associate Professor of Mathematics, Allegheny College*. Cloth. Pages iv+68+4+84. 14.5×22.5 cm. 1943. Ginn and Company, Statler Building, Boston, Mass. Price $1.25.

MATHEMATICS FOR MARINERS, by Chester E. Dimick, *Captain, USCG, United States Coast Guard Academy, New London, Connecticut*, and Cuthbert C. Hurd, *Lieutenant, USCGR, United States Coast Guard Academy, New London, Connecticut*. Cloth. Pages vii+352. 13.5×21.5 cm. 1943. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $2.75.

ORGANIC CHEMISTRY FOR THE LABORATORY, by C. W. Porter and T. D. Stewart, *Members of the Faculty of the College of Chemistry in the University of California*. Cloth. Pages vi+222. 13×20 cm. 1943. Ginn and Company, Statler Building, Boston, Mass. Price $2.00.

STEEL IN ACTION, by Charles M. Parker, *American Iron and Steel Institute*. Cloth. Pages vi+221. 13×19 cm. 1943. The Jacques Cattell Press, Lancaster, Pa. Price $2.50.

SO YOU WANT TO BE A CHEMIST, by Herbert Coith, *Associate Chemical Director, The Procter and Gamble Company*. Cloth. Pages x+128. 12×18.5 cm. 1943. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y.

GENERAL CHEMISTRY, by Horace G. Deming, *Professor of Chemistry, University of Nebraska*. Cloth. Pages x+712. 13.5×21 cm. 1944. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $3.75.

BELOVED SCIENTIST, by David O. Woodbury. Cloth. Pages xiii+358. 15×23.5 cm. 1944. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $3.50.

ELEMENTARY TOPOGRAPHY AND MAP READING, by Samuel L. Greitzer, *Instructor in Mathematics, Bronx High School of Science, New York City*. Cloth. Pages vii+157. 14×22 cm. 1944. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $1.60.

WORKBOOK IN PRE-FLIGHT AERONAUTICS, by Colonel Rollen H. Drake, *Commercial Pilot, Ground School Instructor, Chief, Airmen Agencies Unit of the Civil Aeronautics Administration*. Paper. Pages ix+177. 12.5×19 cm. 1943. The Macmillan Company, 60 Fifth Avenue, New York, N. Y.

BOOK REVIEWS

PHYSICS, A BASIC SCIENCE, by Elmer E. Burns, *Teacher of Physics (Emeritus), Austin High School, Chicago;* Frank L. Verwiebe, *Associate Professor of Physics, Hamilton College, Research Associate, Army Institute;* and Herbert C. Hazel, *Major, U. S. Marine Corps*. Cloth. Pages xii+656. 15×23 cm. 1943. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y.

Here is a new book prepared by three outstanding physics teachers for the pupils of the schools of today. The war has shown definitely some of the past failures long ago known to our science teachers. We hope the war conditions will bring changes in our schools that will correct some of the errors of the past. The authors of this book have known that these condi-

tions have existed for a long time and their book would probably not have differed greatly from its present form had the war not come on. But the war has set the high school defects plainly before many people and these conditions will favor the adoption of a text of this type.

It presents the subject of physics, not just stories about physics, in short, interesting, instructive chapters. These are followed by lists of Summary Questions which emphasize the important ideas of the chapter. Then there is a list of General Questions divided into groups A and B, and a list of problems based definitely on the material of the chapter; finally in many chapters a second list of related problems completes the study. These devices make it possible for any teacher to make definite assignments without a great deal of work on his part. The pupil is thus always supplied with definite thought and problem material requiring specific study and preparation. But it is interesting material that many of the high school students will find fascinating and attractive. The student project at the close of each chapter will no doubt intrigue many fathers and mothers if it is carried out at home.

The section on light is unusual. Most of the mirror and lens constructions are white lines on a black background. They show up well and are carefully made. One wonders, however, why in some cases the rays are bent at only one side of the lens, while in others bending occurs at both sides. Would it nor have been better either to bend the rays at both sides or once at the middle of the lens? A few of the diagrams have little value in showing the student just what the lens does, as in Fig. 51—1, a diagram of the camera.

The book probably contains much more than the majority of classes will be able to cover. Much of this advanced work dealing with alternating currents, radio fundamentals, and nuclear physics can be omitted without any break in the sequence. A few topics along through the book are starred and may be omitted without fundamental loss. The numerical work is nearly all confined to the English system of units but a small amount of time is devoted to the metric system and its importance is clearly stated.

This book is unusual in clarity and form and shows excellent work by both authors and publishers. Figure 71—4 is inverted, a few of the diagrams in light such as 51—1 and 51—7 have little instructional value, and a picture such as Fig. 30—7 is so vague and confused that it is of little value in a textbook. But these are exceptional cases. Practically every illustration has a definite purpose and is both clear and instructive. It is our belief that this book is one of the best in the field for high school use, and we congratulate both the authors and publisher.

G. W. W.

PRACTICAL RADIO COMMUNICATION, by Arthur R. Nilson, *Chief Instructor, Nilson Radio School, New York, N. Y. Lieutenant (Technicist) (Communications) U.S.N.R. (Retired); Member Institute of Radio Engineers,* and J. L. Hornung, *Lieutenant A-V (RS) U.S.N.R.; Member Institute of Radio Engineers; Formerly Radio Instructor, New York University.* Second Edition. Cloth. Pages xxiii+927. 14.5×22.5 cm. 1943. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $5.00.

This is a very elaborate textbook on radio for those who are planning to specialize in the subject. While it covers the fundamentals of electricity, both D.C. and A.C. in about a hundred pages the student should have had an elementary course in electricity and some work in trigonometry preceding the study of this text. For a complete use of all the theory an understanding of vector notation is necessary and some further understanding of mathematics is valuable. Chapters 3 to 8 cover the fundamentals of elementary radio and treat quite thoroughly most of the material usually

given in a first course. In addition there are many devices and considerable theory not usually discussed in an elementary course. Aviation radio, broadcasting and marine radio are discussed in chapters 9 to 16 and furnishes material for more advanced study. Chapter 17 on motors and generators and chapter 18 on storage batteries adequately discuss these topics and can readily be understood by elementary students. This book is an excellent text for those with sufficient mathematical preparaton. It should be in the library for frequent use by all radio students.

G. W. W.

MACHINES, by Charles R. Wallendorf, *Administrative Assistant, Woodrow Wilson Vocational High School, Jamaica, N. Y.*, Frank Stewart, *Department of Applied Physics, Brooklyn Technical High School, N. Y.*, George Luedeke, *Supervisor of Shop Subjects in Vocational High Schools, Board of Education, New York, N. Y.*, and Dominic M. Chiarello, *Department of Applied Electricity, Brooklyn Technical High School, N. Y.* Cloth, pages viii+300. 15.5 cm.×24 cm., 1943, American Book Company, New York City.

This book conforms with the War Department's course outline in Fundamentals of Machines. It can be strongly recommended for use as a test. General Science and Physics teachers will also find it useful as a supplementary text.

Its chief value is in its numerous and wisely chosen applications of the principles of mechanics and heat to our everyday life. Surface tension, for instance, instead of being treated as an interesting phenomenon involving the floating of needles and razor blades on water, is applied to the leakage of various antifreeze liquids in cooling systems. The authors also show by their handling of the subject that they are good teachers, well illustrated by their treatment of theoretical and actual mechanical advantage of page 25. The cuts are excellent, and add considerably to the value of the book. The publishers are to be commended by the attractive binding and make up of the book. Each section of the book is followed by a list of problems or questions or both, and each Chapter is concluded with a good summary. Most of the problems and questions are well chosen, only a very few needing revision.

It is but fair to call attention to some of the weaknesses of the book, minor as they are from the standpoint of the usefulness of the book. Chapter IV is particularly irritating because of such statements and expressions as, "power transmission," "no power is lost in transmission," "a given amount of power can overcome a large resisting force at low speed," "the source of power," "high speed power," and "one uses more power." All these after defining power as the rate of doing work.

Some of the considerable number of small errors will be listed. The common error of considering the oar as a first class lever is included (p. 10). A magnetic compass is said to be balanced at its center of gravity (p. 16). The book states flatly that rolling friction is always greater than sliding friction (p. 57). Stress and strain are defined as the total force and the total deformation respectively (p. 82). The gravitational constant is given as 32 feet per second per second without qualification (p. 144). Mass and weight are said to be numerically equal (p. 142). The "skim" on paint is attributed to evaporation (p. 199).

This reviewer objects to the inclusion of knives and chisels under the heading of wedges. The function of their cutting edges is much more important than the wedge action of such tools. Also, in the study of kinetic energy, the authors fail to treat the most common application of all, hammers and other pounding tools.

The book serves as an example of the folly of introducing unnecessary complexities, not attributable to the authors who but followed the War Department Outline closely. The chapters which attempt explanations in terms of molecules stand in marked contrast to the lucid chapters which make explanations in terms of what can be seen. There is nothing in mechanics and heat that is made a bit more understandable to high school boys by reference to molecules. To bring in the theory adds only confusion.

W. A. THURBER

SYSTEMATICS AND THE ORIGIN OF SPECIES, by Ernst Mayr, *The American Museum of Natural History, New York.* Cloth. Pages xiv+334. 15×23 cm. 1942. Columbia University Press, Morningside Heights, New York, N. Y. Price $4.00.

The outline of good scientific procedure follows somewhat this pattern, (1) there is motivation; that is, a person develops or has suggested to him a working hypothesis, (2) he observes and records facts by which he hopes to prove his hypothesis, (3) he relates and summarizes these facts as he sees them, and (4) he decides that the facts he has collected either agree or disagree with those already known. If he deems it advisable, he develops his theory for the existence of these facts or he decides that they merely substantiate some theory already advanced. We may question his methods, the care with which he made his observations, his reasoning or his conclusions, but never until we are fairly sure our work is equal or superior to his. That men, and particularly scientists working in different fields, frequently come into conflict can be explained only by their lack of familiarity with each other's purposes, materials and methods. If we wish to avoid the stigma of dogmatism, we must acquaint ourselves with the work of others to as great an extent as is humanly possible. All seeming conflicts, when resolved by greater mutual understanding, become non-existent. Your reviewer once heard the great William Jennings Bryan proclaim in a loud voice, punctuated by resounding pummeling of the rostrum, "I don't know anything about evolution, and I don't want to know anything about it!" The proper retort to such statements is, "Either decide to learn something about it, or confine your opinions to subjects with which you are now familiar."

Knowing some of the problems of the systematist only in a very general sense, I will not pretend to evaluate Dr. Mayr's treatise with any great degree of competence. A scientist of Dr. Mayr's ability, coupled with the amount of research and the esteem in which he is held, should recommend this book to anyone interested in the problem of species origin. The concept of the species as well as its origin has undergone many changes since Darwin and Wallace first raised the question. In addition to the older purely morphologic angle, the problem has been attacked from others, including the physiologic, the genetic and the ecologic. Dr. Mayr attempts to correlate these lines of attack so that he may arrive at a greater approximation to the truth and thus a more generally accepted conclusion. Since he is the foremost authority on the birds of Oceania and Indonesia, much of the illustrative material is ornithological. His conclusions, however, are those of a general biologist. To be sure, there may be some, particularly those working in the field of bacteriology and mycology, who might argue that one can't generalize about all the organic world by a study of some highly specialized group. Be that as it may, here is the kind of book that should be brought out occasionally to summarize in compact form the great mass of scientific literature in a particular field. This is valuable not only to acquaint fellow workers with the line of thought the writer is pursuing, his records to date and his methods, but also it should be read by scientists in

general, if they hope to keep up to date on scientific trends and recent opinions.

HOWARD F. WRIGHT

COMMON EDIBLE MUSHROOMS, by Clyde M. Christensen, *Assistant Professor of Plant Pathology, The University of Minnesota.* Cloth. Pages x+124. 14×21 cm. 1943. The Lund Press, Inc. (University of Minnesota), Minneapolis, Minnesota. Price $2.50.

If you believe that one has to be an expert mycologist to collect mushrooms for the table, then this editorial-comment on the back cover should immediately awaken your interest, "Several members of the Press staff were so inspired by this book while it was being edited that they gathered and identified more than twenty-five different kinds of mushrooms in a few days. What is more, they cooked and ate, or dried for later use, over a dozen varieties." The author himself says in the introduction, "With no more time or trouble than it takes to learn to recognize half a dozen different kinds of flowers or shrubs that grow in our gardens we can learn to know an equal number of the choicer mushrooms."

As the title suggests, this book was prepared with a view to increasing the number of collectors of wild mushrooms for food, as well as furnishing a convenient handbook for those who already know a few edible forms and would like to become acquainted with more.

The attractive format is greatly enhanced by sixty-two splendid photographs in black and white taken by the author. In addition, there are four pages in full color showing eighteen species. The few poisonous and forty-seven edible species are described in detail, and each is pictured at least once. There is a section at the end on mushroom cookery to whet the appetite of those unfamiliar with their possibilities and to add to the cookbook of the mushroom gourmet.

HOWARD F. WRIGHT

HANDBOOK OF MICROSCOPIC CHARACTERISTICS OF TISSUES AND ORGANS, 2nd edition, by Karl A. Stiles, *Professor of Biology and Chairman of the Division of Natural Sciences, Coe College.* Paper. Wire-O bound. Pages xi+204. 15×23 cm. 1943. The Blakiston Company, 1012 Walnut Street, Philadelphia, Price $1.50.

Those who have used Professor Stiles' first *Handbook* will need learn only that this second edition has been enlarged, besides including many changes which have been suggested by both teachers and students. While the original volume had printed matter only on one side of the pages, permitting the blank side to be used by the student for drawings and additional notes, the new edition includes extra blank pages at the end of each section.

To those not acquainted with this useful volume, it was prepared with the aim of teaching the characteristics of tissues quickly and for making comparisons with greater facility. This speeding-up of the mechanics of identification leaves the student with more time to spend on the physiological aspects of histology. The relative importance of sub-divisions of the systems is indicated by varying sizes of type, while the "spotting" characteristics are in italics. Comparison of tissues often confused, is presented in tabular form and at the end of each section other tables summarize the tissues and organs of that system. A glossary of terms used is given at the end. This inexpensive, well-bound handbook will find its main use in medical and premedical schools. There, however, it will be found to be very valuable for making possible a clear, organized grasp of the characteristics used in tissues identification.

HOWARD F. WRIGHT

PLANE TRIGONOMETRY, by Arthur W. Weeks, M.A., *The Phillips Exeter Academy*, and H. Gray Funkhouser, Ph.D., *The Phillips Exeter Academy*. Cloth. Pages viii+193. 15.5×23.5 cm. 1943. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $1.75.

This text attempts to proceed by easy stages from the simpler computational side of trigonometry to the more complex parts of the subject. The authors seem to have done a very good job in their attempt. The student is given reasons for study of certain topics, sometimes, as in the discussion of quadrantal angles, it is pointed out that there are objections to various methods of presentation. The discussion of significant figures is very good; it is pointed out that illustrative examples are worked with four place tables, and that lengths will be considered as accurate to four places (it might have been an improvement to give a length as 70.00, rather than 70).

The book starts with a preliminary chapter on logarithms, then takes up the functions of an acute angle and the solution of right triangles Angles of any magnitude are then considered, and the text covers solution of oblique triangles by the sine and cosine laws; the next material relates to the fundamental identities and solution of equations. Topics then follow in this order; radian and mil measure, graphs, addition formulas, multiple angles, inverse functions, more complicated equations and identities, solution of triangles by law of tangents and the half angle formulas. The final chapter is devoted to problems of navigation and vector quantities.

There are no answers given in the text, nor are tables bound with the book. The number of exercises is unusually large, more than could possibly be assigned in a single course.

CECIL B. READ
University of Wichita

ANALYTIC GEOMETRY, by Frederick H. Steen, Ph.D., *Associate Professor of Mathematics, Allegheny College*, and Donald H. Ballou, Ph.D., *Assistant Professor of Mathematics, Middlebury College*. Cloth. Pages vii+206+9. 15×23 cm. 1943. Ginn and Company, Boston, Mass. Price $2.40.

This text, rather thin in appearance, covers in considerable detail the material of plane and solid analytic geometry which might be included in a first course. The treatment is to a large extent traditional, although interesting variations are used, as in the rotation of axes and the development of the normal form of the equation of a line. This last seems rather more complicated than the usual development. The number of exercises varies, being rather scanty in spots and more than ample in others. The last nine pages give answers to the majority of the exercises. An interesting veature is the provision of "orals," consisting of simple exercises valuable for drill purposes.

In a few places the reviewer would prefer a little more explanation—on page 53 the proof of a theorem is apparently a glance at a figure; on page 152 it is implied that simultaneous solution of the equations will give intersections in polar coordinates, it not being emphasized that this may not give all intersections; it is not made clear that rectangular and parametric equations are not always equivalent.

Whether or not one wishes to include all the material in the text in any given course, this book merits consideration because the treatment is sufficiently detailed to cover most questions which will arise in later undergraduate courses—the student will find it a reference worth keeping.

CECIL B. READ

ELECTRICITY, by Charles A. Rinde. Cloth. Pages xii+466. 16×23.5 cm. 1943. Harcourt, Brace and Company, Inc., 383 Madison Avenue, New York, N. Y. Price $1.96.

An outgrowth of the present stepped-up demand for a practical knowledge of electricity, this book is an excellent collection of principles and practical applications covering the fundamentals of the field of electricity as suggested by the War Department's outline, ***Fundamentals of Electricity*** (PIT-101).

It is a book that can be used for self study as well as for class-room use. It is adaptable to anyone desiring to learn about electricity, even though they have had no previous acquaintance with the subject. The wealth of illustrations and modern and timely applications draw the interest of one already versed in the principles.

One of the great present day difficulties in training many young men and women in the specialized fields of war work is their general lack of experiences with electrical apparatus. This book does much to remedy this lack by using well drawn illustrations and diagrams of the working principles of the apparatus. Many of the applications given center around both military and civilian war demands.

The book includes the fundamentals of alternating currents and their circuit characteristics in as non-mathematical a manner as possible but sufficiently to form the basis for many A.C. applications. Practically all of the modern electronic control devices are discussed and illustrated, including communications and X-ray.

The structure and arrangement of the book is excellent. The summary of ideas to be reinforced at the end of each unit makes use of italics and heavy type for emphasis. Excellent self-testing exercises cover each unit. Suggestions for experiments and investigations covering the material of the unit are a useful teaching aid.

H. R. VOORHEES

PRINCIPLES AND PRACTICE OF RADIO SERVICING, by H. J. Hicks, M.S., *Associate Radio Engineer, Aircraft Radio Laboratory,* Wright Field, Dayton. Second Edition. Cloth. Pages xii+391. 15×23 cm. 1943. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $3.50.

This second edition of a well accepted text has been thoroughly rewritten, yet maintains the form and objectives of the first edition.

This is not a servicing manual. It does not attempt to give specific servicing data for various makes of radio, but rather discusses the general principles of circuits and servicing apparatus, which, if properly learned, may be applied in practice to any servicing problem. The text is foundational for servicemen and students of servicing methods. Sufficient electrical theory is given so that one with but little technical background should be able to grasp and apply it to the special problems of servicing.

Test equipment is discussed and design data given; not so much that the serviceman will build his own equipment, but so that he may use good judgment in the purchase of his equipment. This edition gives more attention to signal tracing methods and has incorporated discussions of frequency modulation and modern antenna systems.

The author again devotes the last chapter to the business problems of the serviceman, giving him helpful suggestions as to methods of advertising, bookkeeping, and cost estimation.

H. R. VOORHEES

EXPERIMENTAL ELECTRONICS, by Ralph H. Müller, *Professor of Chemistry, New York University;* R. L. Garman, *Assistant Professor of Chemistry, New York University;* and M. E. Droz, *Assistant Professor of Chemistry, New York University.* Cloth. Pages xv+330. 14.5×22.5 cm. 1942. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price $3.50.

Almost every teacher of electronics has had to devise the experimental work for his course. Recently some of the results of this work have appeared in manual and textbook form. This is particularly fortunate at this time when the teaching of electronics has been so accelerated by war and industrial demands.

In this new text of experimental electronics the authors have given the outgrowth of their experiences in teaching electronics to students of widely varying backgrounds and interests, including students and research workers in biology, and chemistry, as well as in engineering. The point of view and statement of problem is therefore not narrowed to the communications field as is so often the case.

Although the book covers the fundamental theory of the electrical circuits in review form, the student who already knows this material from earlier courses will have a distinct advantage. The theory of each experiment is discussed, but without derivation, so that the student would benefit by supplementary lecture material or the use of a standard textbook in electron physics.

The experiments are designed for a mature level, and not only teach the fundamental principles of electron applications but also point the way to many laboratory uses of an advanced nature. To take full advantage of the experimental problems would require a well equipped laboratory.

The arrangement and form of the book is excellent as a laboratory text rather than a mere manual. The procedures are given in an understandable form, showing that methods have been well worked out. Excellent reading references are given for each phase of the problem which should prove exceedingly valuable to the research student with an ample library at hand.

H. R. VOORHEES

SIMPLIFIED INDUSTRIAL MATHEMATICS, by John H. Wolfe, Ph.D., *Supervisor of Ford Apprentice Training, Ford Motor Company, Dearborn, Michigan;* William F. Mueller, A.B., *Principal of Ford Aircraft Apprentice School, Ford Motor Company, Dearborn, Michigan;* and Seibert D. Mullikin, B.S., *Principal of Ford Airplane Apprentice School, Ford Motor Company, Willow Run, Michigan.* Cloth. Pages xiii+281. 1942. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $2.00.

The authors state that their purpose in preparing this book is to familiarize newly recruited students in the shortest possible time with the essentials of elementary industrial mathematics which is so urgently needed by all present-day mechanics. It is especially designed for the technical training of skilled and semiskilled craftsmen whose trade requires the direct application of mathematical knowledge.

The topics covered include operations with common and decimal fractions, square root, ratio and proportion, percentage, geometry, the trigonometric functions, formulas, precision instruments, screw threads, and gears. The mathematical principals are not developed or proved but are carefully stated and their application illustrated through examples. This step is followed by an ample supply of practice exercises for the student.

While the text is intended for classroom use the explanations are simple enough and adequate for use by the person who must study alone. The book appears to be a very useful addition to the field.

G. E. HAWKINS